Program Title: Machining Level - II

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Acronyms

CI	Cast iron
Ft	Foot /Feet
H.S.S.	High Speed Steel
in.	Inch /Inches
M	Metre/s
Mm	Millimetre/s
Rpm	Revolution per minute

Introduction to the Module

In ***machining*** filed; ***precision shaping/planning/slotting operations*** to observe safety precautions, to determine job requirements, to perform precision shaping operations, to perform precision planning operations, to perform precision slotting operations and to check component for conformance to specification.

This module is designed to meet the industry requirement under the ***machining*** occupational standard, particularly for the unit of competency: **Perform precision shaping/planning/slotting operations**.

Module units

This module covers the units:

- Safety precautions
- Job requirements
- Precision shaping operations
- Precision planning operations
- Precision slotting operations and
- Component for conformance to specification

Learning objectives of the Module

At the end of this session, the students will able to:

- Observe safety precautions
- Determine job requirements
- Perform precision shaping operations
- Perform precision planning operations
- Perform precision slotting operations
- Check component for conformance to specification

Module Learning Instructions:

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the "LAP test" giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit One: Safety Precautions and *Procedures*

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Safety procedures and precautions
  - Standard operating procedures,
  - Safe working procedures
  - Operation sheets

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Observe correct safety procedures and precautions
  - Follow standard operating procedures,
  - Apply safe working procedures
  - Use operation sheets

1. Safety procedures and precautions

The importance of safety was realized a century ago because of the occurrence of millions of industrial and other accidents, which resulted in death, or disablement of industrial employees every year.

As always we should be aware of safety requirements and attempt to observe safety rules in order to eliminate serious injury to ourselves or others.

Safety precautions for specific operations are detailed in the text along with the description of the operation. Learn each operation thoroughly before attempting to carry it out. All safety precautions must be observed when working with the shaping, planing, slotting and broaching machine. Follow all safety instructions detailed in the workshop and make safe working practice a habit.

Instructions on how to operate shaping machine are given in this TTLM as a guide to correct working. They are not intended to give the one best way of working. Be guided by your instructor in systematic, safe, and efficient working practice suitable for your workshop.

Causes of Accidents

The accidents may take place due to

- Human causes,
- Environmental causes and
- Mechanical causes.

a. Human Causes

- Accidents may occur while working on unsafe or dangerous equipment or machineries possessing rotating, reciprocating and moving parts.
- Accidents occur while operating machines without knowledge, without safety precautions, without authority, without safety devices
- Accidents generally occur while operating or working at unsafe speed
- Working for long duration of work, shift duty etc.
- Accidents commonly occur during use of improper tools
- Accidents may occur while working with mental worries, ignorance, carelessness, nervousness, dreaming etc.
- Accidents occur because of not using personal protective devices

b. Environmental Causes

- Working at improper temperature and humidity (causes fatigue to the workers so a chance of accidents increases with workers having fatigue).
- The presence of dust fumes and smoke in the working
- Poor housekeeping, congestion, blocked exits; bad plant layout etc. may cause accidents.
- Accidents occur due to inadequate illumination.
- Improper ventilation in the plant may also leads to industrial accidents**.**

c. Mechanical Causes

- Continued use of old, poor maintained or unsafe equipment may result in accidents.
- Accidents commonly occur due to use of unguarded or improper guarded machines or equipment
- Unsafe processes, unsafe design and unsafe construction of building structure may lead to accidents in the plant.
- It can occur due to improper material handling system and improper plant layout.
- May occur due to not using of safety devices such as helmets, goggles, gloves, masks etc.

d. Other general causes of accidents in workshops

- Because of ignorance to work with, equipment, hand tools, cutting tools and machine tools.
- Operating machine and equipment's without knowledge
- Extra curiosity to work without knowing
- Poor working conditions. Because of speedy work

- Improper method to work
- Due to use of improper tools
- Because of lack of discipline
- Uninterested in work
- Due to carelessness
- Due to over confidence
- Bad working environment
- Excessive over times duty by industrial workers
- Dangerous materials with which to work
- Lack of cleanliness
- Due to poor planning

1.1. Standard operating procedures

Procedural Standards

Before beginning any job on the shaper, you should thoroughly study and understand the blueprint or drawing from which you are to work. In addition, you should take the following precautions:

- Make certain that the shaper is well oiled.
- Clean away ALL chips from previous work.
- Be sure the cutting tool is set properly; otherwise, the tool bit will chatter. Set the tool holder so the tool bit does not extend more than about 2 inches below the clapper box.
- Be sure the piece of work is held rigidly in the vies to prevent chatter. You can seat the work by tapping it with a Babbitt hammer.
- Test the table to see if it is level and square. Make these tests with a dial indicator and a machinist's square, as shown in figure 1.1. If either the table or the vies is off parallel, check for dirt under the vies or improper adjustment of the table support bracket.
- Adjust the ram for length of stroke and position. The cutting tool should travel 1/8 to 1/4 inch past the edge of the work on the forward stroke and 3/4 to 7/8 inch behind the rear edge of the work on the return stroke.

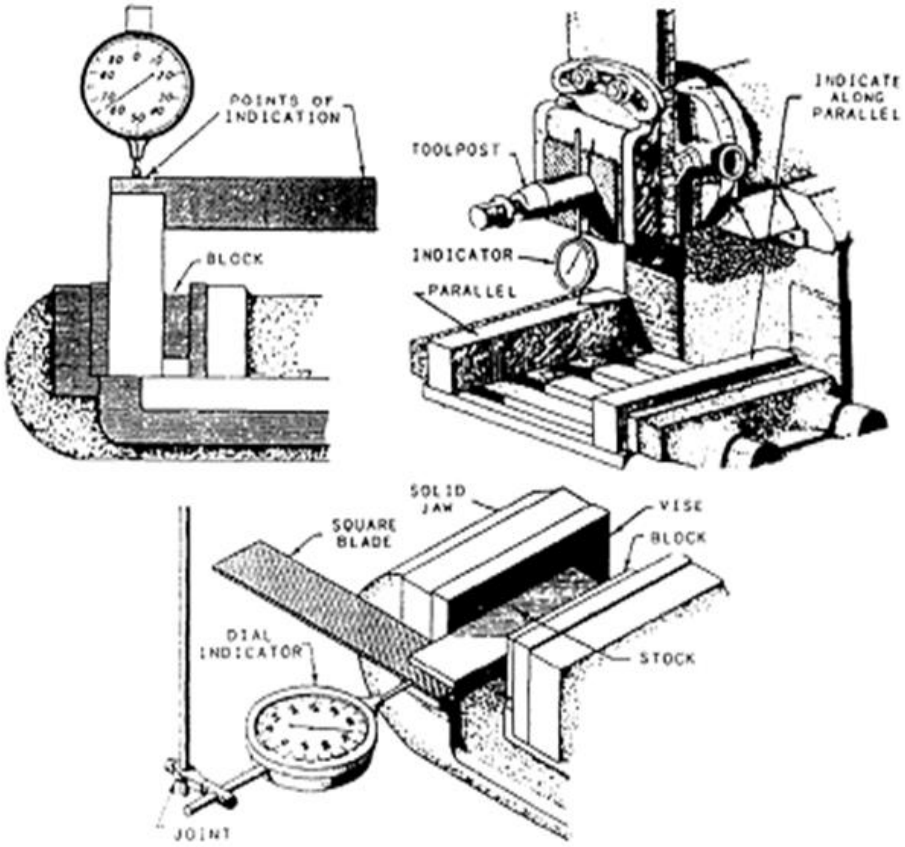


Figure 1.1. Squaring the table and the vice

1.2. Safe working procedures

- As with any machine tool, carefully examine a shaper to be sure it is in safe operating condition. The machine should also be lubricated according to the manufacturer's specifications.
- Never attempt to operate these machines while your senses are impaired by medication or other substances.

Personal Safety:

- Always wear approved type eye protection
- Do not attempt to use unless all guards and safety devices are in place and securely attached.
- Stop machine before making measurements or work adjustment.
- Remove your watch, rings etc. before using the machine.
- Wear glasses, short sleeves, no tie, no rings, no trying to stop the work by hand. Stop the machine before trying to check the work. Don’t know how it works? “Don’t run it.” Don’t use rags when the machine is running.
- Personnel working with machines must be aware of the risks involved and follow safe work practices.

Machine Safety:

- Never attempt to operate a machine until you have been instructed properly.
- Never place a tool on a boring machine before checking it for soundness.
- Adjust the cutter and work piece properly before any operation
- Start the machine and feed the cutter into the work
- The machine should not be operated at speed higher than specified.
- Clean the machine after operation.
- Unguarded moving parts of machines/equipment and the sudden or uncontrolled release of their power systems can result in serious injuries.

Workplace Safety

- Keep all tools clear of a work table.
- Change coolant fluid before it becomes contaminated.
- Wipe up all spilled coolants from the floor around the machine right away
- Put tools and equipment in their proper position

1.3. Operation sheets

Operation sheet is a sequence of operation plan. Which is prepared based on the information provided on the job sheet or verbal instructions of the component to be machined has to ready for producing expected parts / components / with required specification.

Sequencing refers to the order in which activities occur in the operations process. But there are a lot of operations are performed by different machines

Self-check - 1

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.** (1 point for each)

1. The machine should not be operated at speed higher than specified
2. Unguarded moving parts of machines/equipment and the sudden or uncontrolled release of their power systems can result in serious injuries

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives. (1 point for each)

1. Which one of the following is characteristics of work shop safety rule?

   A. Keep the machine clear of tools B. Oil rugs must be placed in approved safety containers
   C. avoid horse play D. all

2. Accidents may take place due to _____

   A. Human causes B. Environmental causes
   C. Mechanical causes D. All

Part III: Marching - Instructions: For the following questions matching from **"B" to "A" column** (1 point for each)

No.	"A" Column	"B" Column
_____ 1.	Operation sheet	A. Wipe up all spilled coolants from the floor around the machine right away
_____ 2.	Personal Safety	B. Always wear approved type eye protection
_____ 3.	Workplace Safety	C. A sequence of operation plan

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers. (2 points)

1. _____ is important in order to produce the required work
2. _____ is the first best method of job planning

ANSWER SHEET

True or False

1. True
2. True

Multiple Choice

1. (d)
2. (d)
3. (b)
4. (b)

Marching

1. C
2. B
3. A

Short Answer Questions

1. To plan sequence of operations
2. To interpret the instruction of the given job sheet

Unit Two: Determine Job Requirements

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Interpretation of drawings, sequence of operations and selection of **tools**
  - Cutting tools
  - Tool holders
- Cutting parameters
  - Feeds
  - Speeds
  - Depth of cut
  - Length of Cut

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Interpret drawings, sequence of operations and select **tools**
- Determine cutting parameters

2. Job requirements

In manufacturing workshop in order to produce the required work (as customer need). Worker or operator has to perform some operations. It is important that the sequence of operations be carefully planned in order to produce a part quickly and accurately. Following a wrong sequence of operation can often result in spoiled work. The best method of job planning is first interpreting the instruction of the given job sheet or verbal instructions correctly, and arrange the sequence of operation to plan technically to obtain the given components to the required properties.

Interpretation means reading and understanding the information given points engineering drawing, job sheet or verbal instructions; Reading, interpreting and following information on written job instructions, specifications, standard operating procedures, manufacturers manual and instructions, chart, list, drawings and applicable reference documents as organizational / company rule and regulation.

2.1. Interpreting drawings, sequence of operations and selecting tools

This section covers several machining operations that are used to machine straight and open external or internal surfaces:

- Shaping, planning and slotting can be defined as the process of removing metal from a surface in horizontal, vertical and inclined position to produce a flat or plane surface, slots and grooves by means of a relative reciprocating motion between the tool and work piece.
- The difference between the three processes of shaping, planing and slotting is that in shaping and slotting, the tool is reciprocating and the work piece is fed in to the cutting tool while in planning, the work piece is reciprocating and the tool is fed in.
- The tool reciprocates horizontally in the shaping and vertically in slotting.
- The cutting is intermittent in all the three processes because in the relative reciprocating motion the tool cuts only in forward- working (or cutting) stroke followed by the idle-return stroke.

- The machine tool used for shaping operation is called shaper. It is designed for machining flat surfaces on small sized jobs. If the size of the job is large, then planing is used.
- *Planing* and *shaping* are similar operations, which differ in the kinematics of the process. Planing is a machining operation in which the primary cutting motion is performed by the workpiece and feed motion is imparted to the cutting tool. In shaping, the primary motion is performed by the tool, and feed by the workpiece:

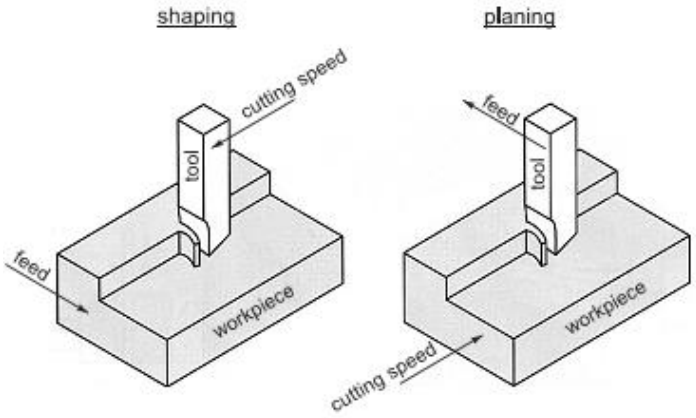


Figure 1.2. Kinematics of shaping and planing.

2.2. Shaper machine

The metal shaper *(Figure 2.1.)* was developed for the purpose of removing metal to produce a flat surface. This flat surface may be machined horizontally, on an angle, or in a vertical plane. The work is held in a vise or fastened to the table. A cutting tool is driven back and forth by a ram which travels in a horizontal plane with a reciprocating motion. The tool peels a chip off the work on each forward stroke only.

Because of the versatility of the vertical milling machine, many operations previously performed on a shaper are now done on a vertical mill more quickly and easily. Therefore, only the basic shaper controls and machining operations will be covered in this section, since the work setups in both machines are basically the same.

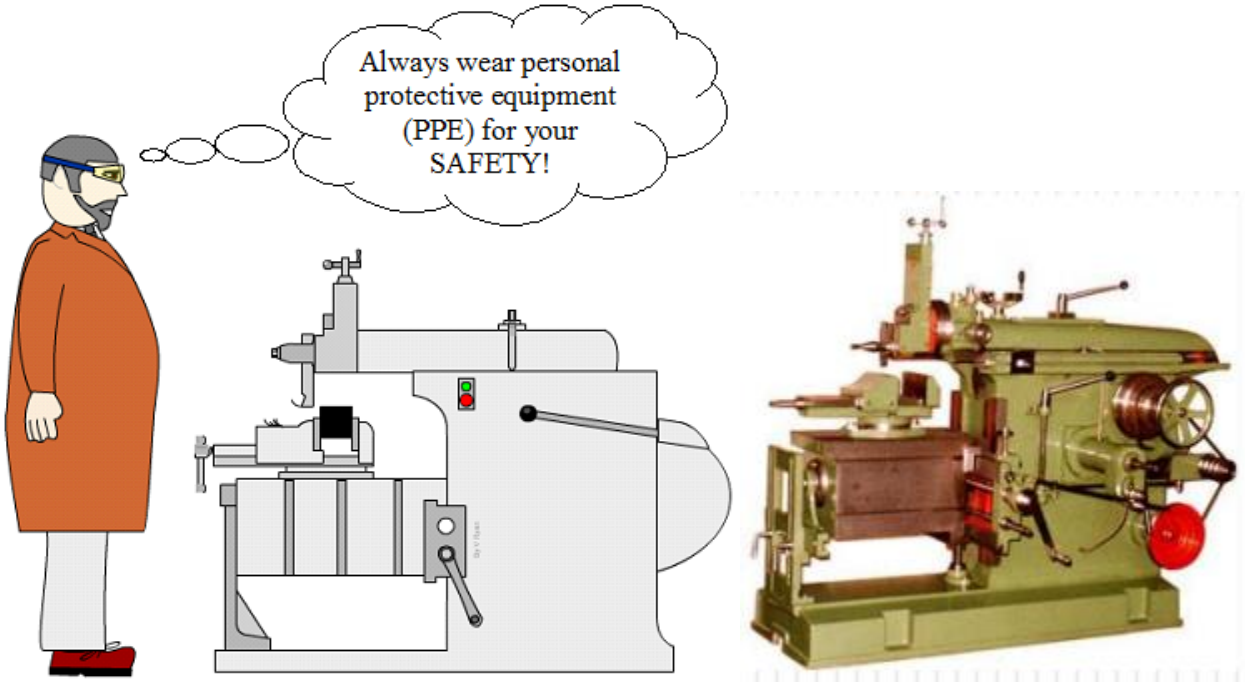


Figure 2.1. Shaper Machine

- The tool reciprocates horizontally in the shaping and vertically in slotting.
- The cutting is intermittent in all the three processes because in the relative reciprocating motion the tool cuts only in forward- working (or cutting) stroke followed by the idle-return stroke.
- In a shaper, the work piece is held stationary during cutting, while the tool reciprocates horizontally. the feed and depth of cut are normally provided by moving the work. Such shaper is called a horizontal shaper.

- Shaping machines are the reciprocating type of machine tools in which the work piece is held stationary and the tool reciprocates.
- Most shapers have reciprocating motion in horizontal position (horizontal shapers) but shapers are also designed with reciprocating motion in vertical position (vertical shapers) or slotting machines or slotters.
- Shapers use a reciprocating motion
  - For ward stroke (cutting motion)
  - Backward stroke (noncutting stroke)
- Shapers are used to produce primarily flat surfaces by means of single or multiple cutting tools.
- The size of a shaper (*Figure 2.2.*) is determined by the largest cube which it can machine. For example, a 14-in. shaper can machine a block 14 in. x 14 in. x 14 in.; a 300-mm shaper can machine a block 300 mm x 300 mm x 300 mm.

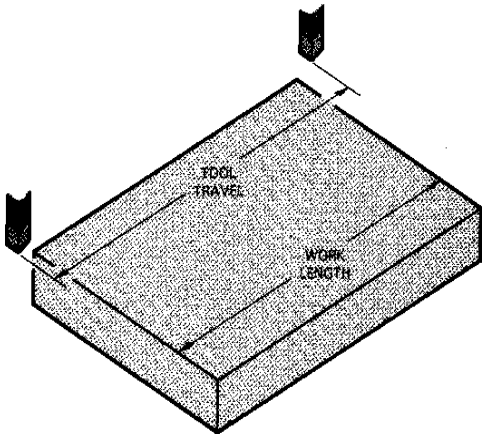


Figure 2.2. Shaper size is determined by maximum work length that can be machined in one pass.

Use of Shaper operations

- Flat surfaces,
- A block square and parallel,
- Angular surfaces,
- Serrating - operation performed on a surface to form a series of equally spaced grooves, which are often used on wide jaws, plates, washers and other parts that are intended to provide a good grip

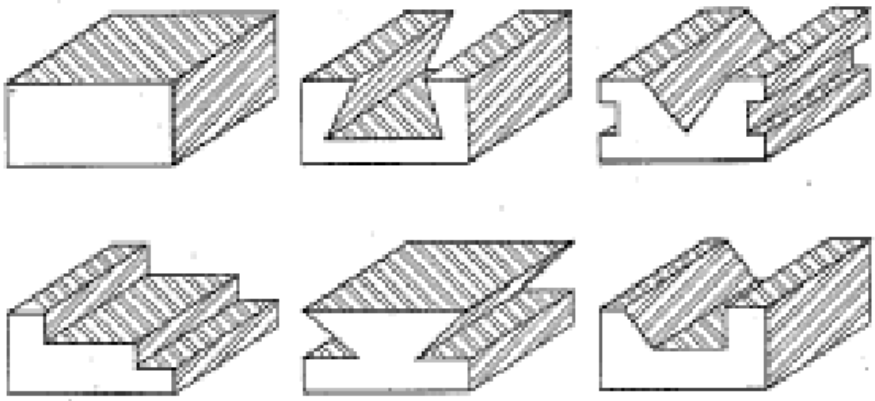


Figure 2.3. Components manufactured by the shaping process.

2.2.1. Shaper Parts

Shaping is performed on a machine tool called a *shaper*. To operate a shaper successfully, a knowledge of the main operative parts and their function is necessary.

The major components of a shaper are the *ram*, which has the *toolpost* with cutting tool mounted on its face, and a *worktable*, which holds the part and accomplishes the feed motion.

Main parts of shaper

- **Frame.**
- The ***ram*** is a semi-cylindrical form of heavy construction that provides the forward and return strokes to the cutting tool. It contains the *ram-positioning mechanism* and the toolhead.
- **Ram** moves in adjustable slide rails. The stroke length and position can be adjusted.
- **Cross-rail**- It is itself adjustable side rails and carries the table on horizontal slide rails.
- **Table** has T-slots and holes to clamp works piece. The setting motion is vertical and the feed motion is horizontal. *The **table** is fastened to the **cross- rail**;* it provides a *support for the work to* be machined. It can be raised or *lowered by the elevating screw and* moved away from or toward the operator by hand with the crossfeed screw, or by power with the automatic feed mechanism.
- **Main gear box** - The rotary movement of the motor is transmitted the crank gear by change-over gear box (3 to 8 r.pm). The direction of motion is changed by a crank and rocker

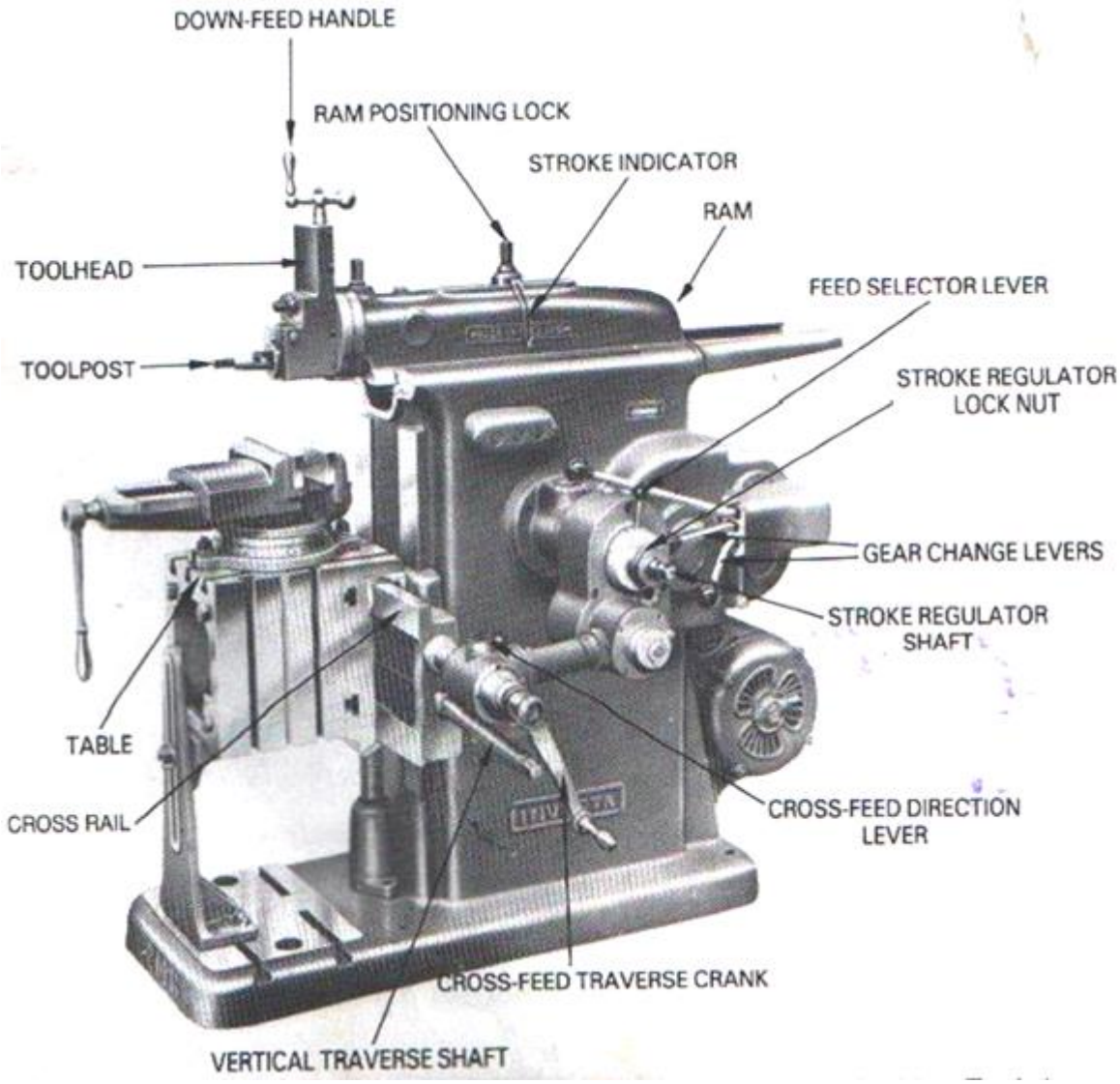


Figure 2.4. The main parts of a crank shaper. (Courtesy Elliott Machine Tools.)

- The ***ram-adjusting shaft*** *is used to change* the position of the stroke and the ***ram- positioning lock*** **or** ***clamp*** locks the ram in a fixed position.
- The ***toolhead*** (*Figure 2.5.*) is fastened to the ram to hold the toolholder and the ***clapper box*** which allows the cutting tool to raise slightly on the return stroke.
- The ***downfeed handle*** provides a means of feeding the cutting tool to any given dimension or depth of cut in either thousandths of an inch or hundredths of a millimeter; as measured on its graduated collar.
- The ***cross feed traverse crank*** *is* used to provide a horizontal movement to the table in either thousandths of an inch or hundredths of a millimeter with the use of the

graduated collar. This screw is used to move the table longitudinally under the cutting tool.

- The ***cross feed direction lever*** may be engaged in a ratchet to provide an automatic feed to the table.
- The ***vertical traverse shaft*** is used to lower or raise the table.
- The ***stroke-regulator shaft*** adjusts the length of stroke required and the ***stroke-regulator lock nut*** is used to lock the mechanism in a fixed position. The ***stroke indicator*** provides a guide when adjusting the shaper to the proper length of stroke required.

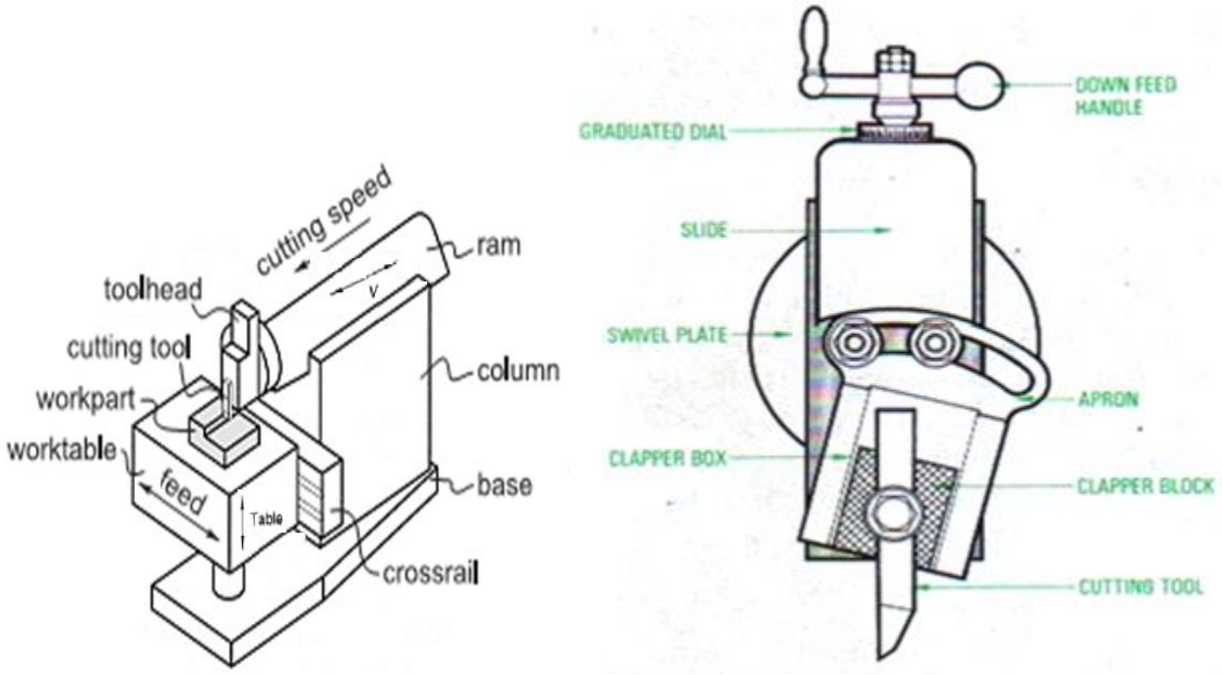


Figure 2.5. The main components of a shaper and parts of a shaper tool head. (Courtesy Cincinnati Shaper.)

2.2.2. Types of Shaper

The most common type of shaper is horizontal shaper they can be:

- Mechanically driven (crank and rocker)
- Hydraulically driving (cylinder and piston)

The three types of shapers commonly found in a machine shop are the crank, gear, and hydraulic-type shapers.

A. Crank Shaper

The crank shaper (*Figure 2.4.*) is the type most commonly used. Its ram is given its reciprocating motion by means of a rocker arm operated by a crank pin from the main driving gear, or "bull wheel." The forward stroke of the shaper occurs when the crank pin is in the upper portion of the rocker arm or 220° of the cycle. The return stroke occurs when the pin is in the lower portion or 140° of the cycle This action causes the return stroke to be faster than the forward stroke on a 3:2 ratio.

2.3 Principle of the crank-type shaper

There are several mechanical methods of driving the reciprocating shaper ram, the crank-type being the most commonly used.

- The quick return of the ram of the back or non cutting stroke is obtained when the crank pin is traveling through 140 degree of the cycle.
- The crank pin will pass through 220 degree of the cycle during the cutting stroke or forward stroke.
- The direction of motion is changed by a crank and rocker
- The motor drives the crank wheel (driving wheel) over the main gear box. The crank is seated in the drilling wheel and can be shifted radially. This carries with it the sliding block which guides in the rocker arm and sets its' reciprocating motion.
- The crank pin runs in its circular path at uniform speed.
- It must travel a longer distance in its working stroke α (longer time), and a shorter distance in the return stroke β (less time), the speed is alternately higher and lower. The longer the stroke the greater is the difference in speeds

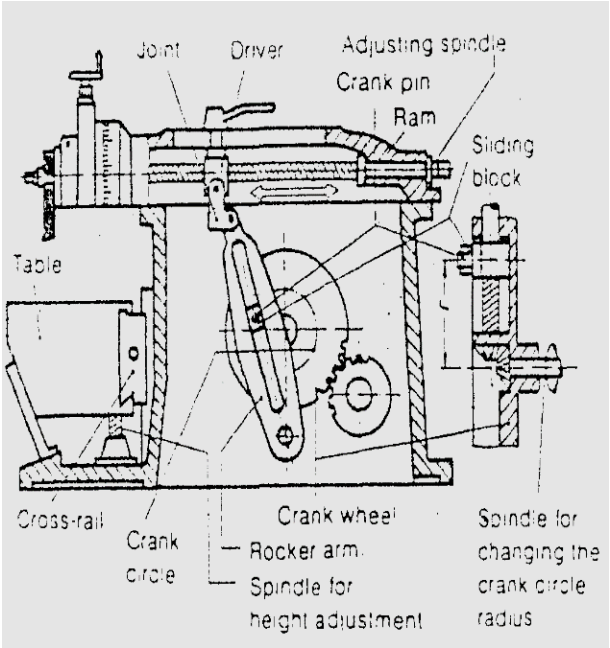


Figure 2.7. (A) Principle of the crank type shaper

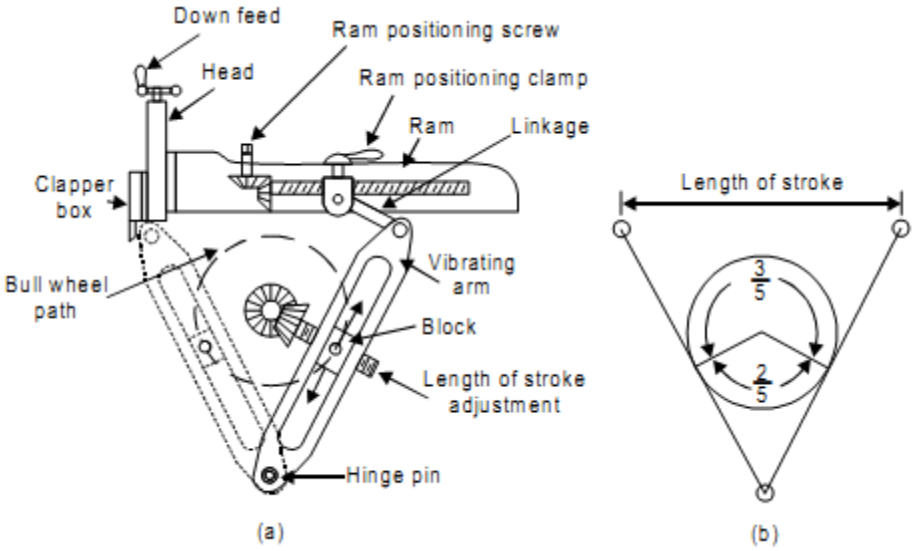


Figure 2.7. (B) Crank and slotted link mechanism

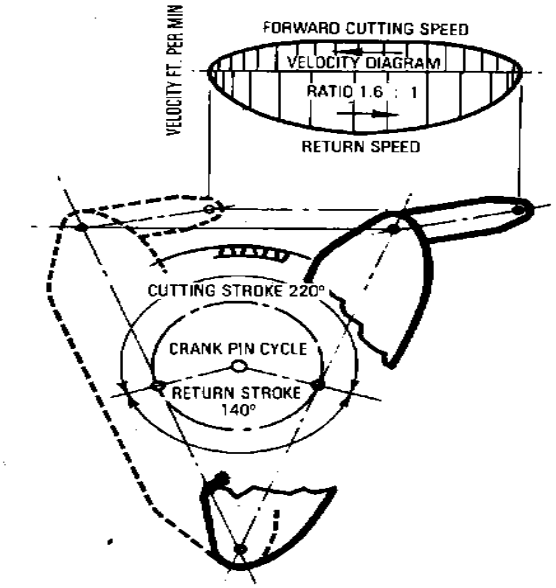


Figure 2.8. The cycle of the crank type shaper

B. Gear Shaper

The gear shaper obtains the drive for the ram from a gear and a rack connected to the ram. This shaper also has a mechanism that provides a quick return for the ram.

C. Hydraulic Shaper

The hydraulic shaper is driven by the movement of a piston in a cylinder of oil and is controlled by a valve mechanism connected with the oil pump. Oil pressure provided by the pump forces the operating cylinder, connected to the ram, forward. A reversing valve causes the cylinder to reverse and move

the ram backward. Hydraulic shapers are best suited for using carbide cutting tools because of the constant feed rate.

Principle of Hydraulic shaper

Hydraulically driven shapers are similar in nearly all respects to the crank; only the drive principle is different.

Main advantage of a hydraulic shaper

- It provides a uniform positive motion
- A wide range of speeds and feeds is available
- Speeds and feeds are independent and constant during the cutting stroke
- The speeds and feed can be adjusted without stopping the shaper
- Cutting speeds and feeds are shown on a dial

Hydraulic ram drive

- The motor drives the pumps. The quantity of oil changes the speed of the ram, which is changed by swiveling the pump.
- The reversal of its **direction of movement, stroke length** and **position are changed by a trip dogs**.
- ***Working stroke*** - when the oil flows into the cylinder chamber V1, the ram speed is low, because a large cylinder volume has to be filled; the thrust force is high, because of the oil presses is against the large piston surface.
- ***Return stroke*** - The oil flows into the cylinder chamber V2. The ram speed is high, because a smaller cylinder volume has to be filled the thrust force is low because the oil pushed against a smaller piston surface.

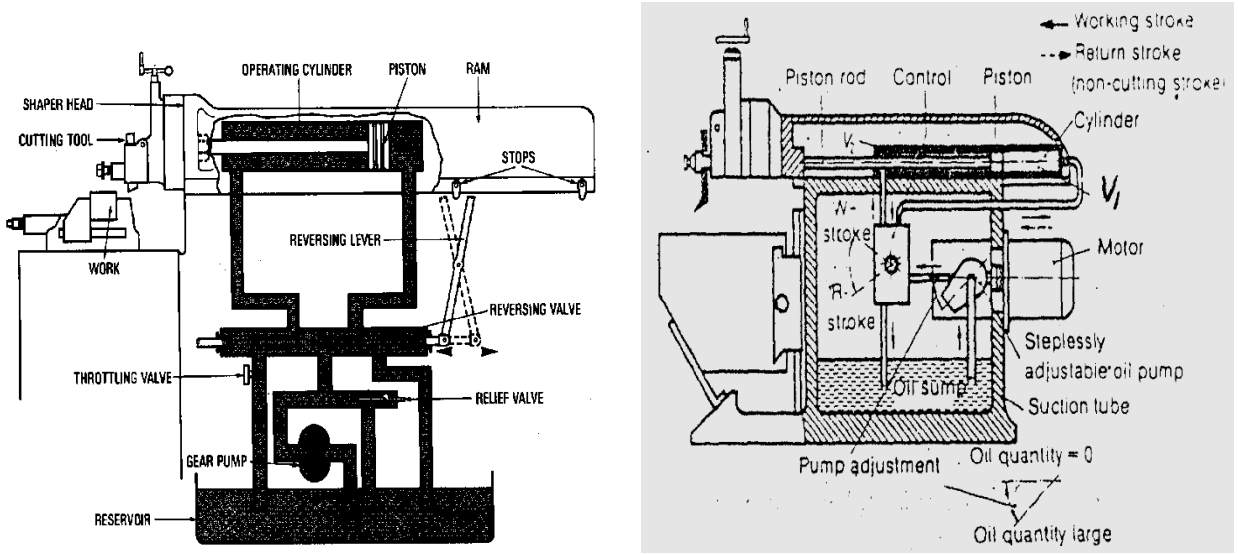


Figure 2.9. principle of hydraulic shaper

2.3. Cutting tools

Cutting tools for shaping and planing

Cutting tool for shaping or planing is essentially the same single-point cutting tool that is used in turning. The only difference is that the cutting tool for planing and shaping must be more rigid to withstand the higher impact cutting forces. The clearance angle must be bigger to avoid plunging of the cutting tool into the machined surface during the quick return of the ram over the workpiece.

Planing and *shaping*: these operations are used to machine straight open mainly external surfaces with a single-point cutting tool.

2.4. Tool holders

The various accessories used to hold planer or shaper work may make the difference between a superior job and a poor job. There are no set rules on the use of planer accessories to clamp down a piece of work results will depend on your ingenuity and experience.

Various types of tool holders made to hold interchangeable tool bits are used to a great extent in planer and shaper work Tool bits are available in different sizes and are hardened and cut to standard lengths to fit the tool holders. The tool holders that you will most commonly use are described in the following list and shown in figure 2.10:

1. Right-hand, straight, and left-hand tool holders used in most common shaper and planer operations.
2. Gang tool holders especially adapted to surface large castings. With a gang tool holder, you make multiple cuts with each forward stroke of the shaper. Each tool takes a light cut and there are fewer tendencies to “break out” at the end of a cut.
3. Swivel head tool holders are universal, patented holders that you can adjust to place the tool in various radial positions. This feature allows you to convert the swivel head tool holder to a straight, right-hand, or left-hand holder at will.
4. Spring tool holders have a rigid, U-shaped spring that lets the holder cap absorb a considerable amount of vibration. This tool holder is particularly good for use with formed cutters, which have a tendency to chatter and dig into the work.

5. Extension tool holders are adapted to cut internal keyways, spines, and grooves on the shaper. You can adjust the extension arm of the holder to change the exposed length and the radial position of the tool.

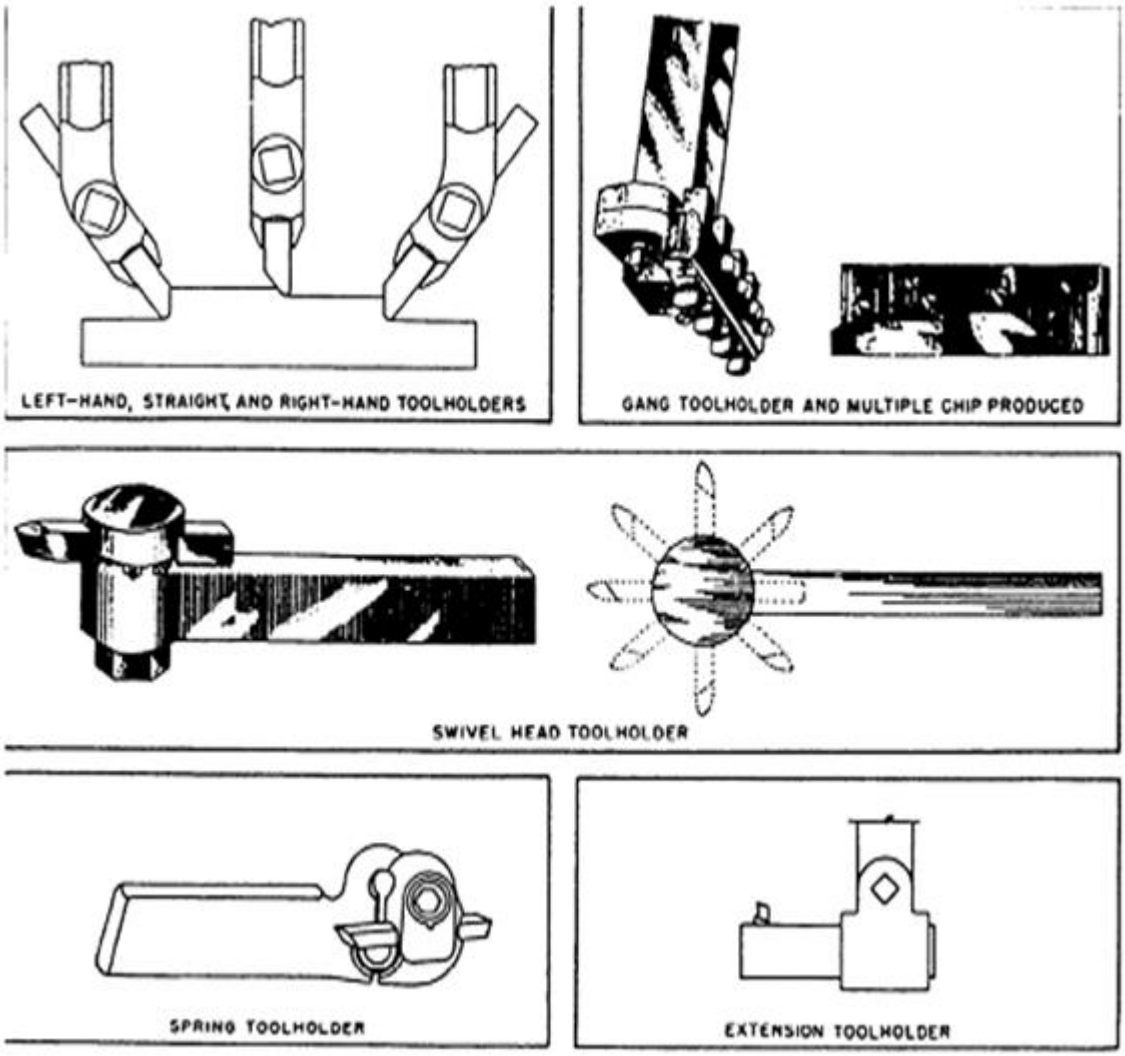


Figure 2.10. Tool holders

Tool Head

The tool head of a shaper performs the following functions: -

1. It holds the tool rigidly,
2. It provides vertical and angular feed movement of the tool, and
3. It allows the tool to have an automatic relief during its return stroke.

The various parts of tool head of shaper are apron clamping bolt, clapper box, tool post, down feed, screw micrometer dial, down feed screw, vertical slide, apron washer, apron swivel pin, and swivel base. By rotating the down feed screw handle, the vertical slide carrying the tool gives down feed or angular feed movement while machining vertical or angular surface. The amount of feed or depth of cut may be adjusted by a micrometer dial on the top of the down feed screw. Apron consisting of clapper box, clapper block and tool post is clamped upon the vertical slide by a screw. The two vertical walls on the apron called clapper box houses the clapper block, which is connected to it by means of a hinge pin. The tool post is mounted upon the clapper block. On the forward cutting stroke the clapper block fits securely to the clapper box to make a rigid tool support. On the return stroke a slight frictional drag of the tool on the work lifts the block out of the clapper box a sufficient amount preventing the tool cutting edge from dragging and consequent wear. The work surface is also prevented from any damage due to dragging.

Holding the work

One way to hold down work on the worktable is by using clamps attached to the worktable by bolts inserted in the T-slots. Figure 2.11. shows a step block that you can use with clamps when you need to clamp an irregularly shaped piece of work to the planer table. One way to do this is illustrated in figure 2.12; where an accurately machined step block is used with a gooseneck clamp. Figure 2.13. illustrates correct and incorrect ways to apply clamps. You can use jacks of different sizes to level and support work on the planer table.

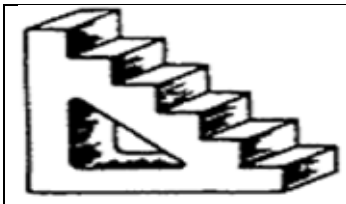


Figure 2.11. Step block

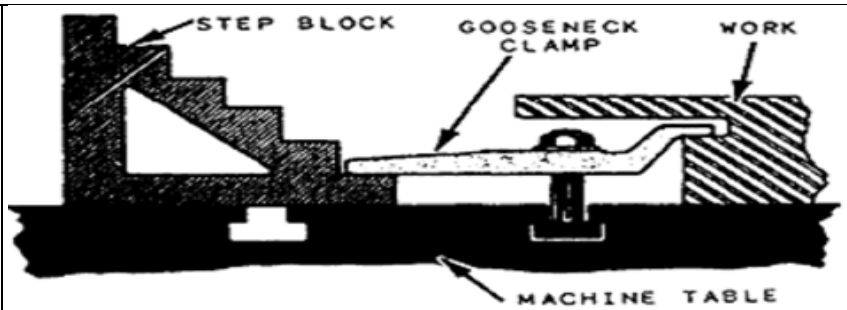


Figure 2.12. Application of step block and clamp

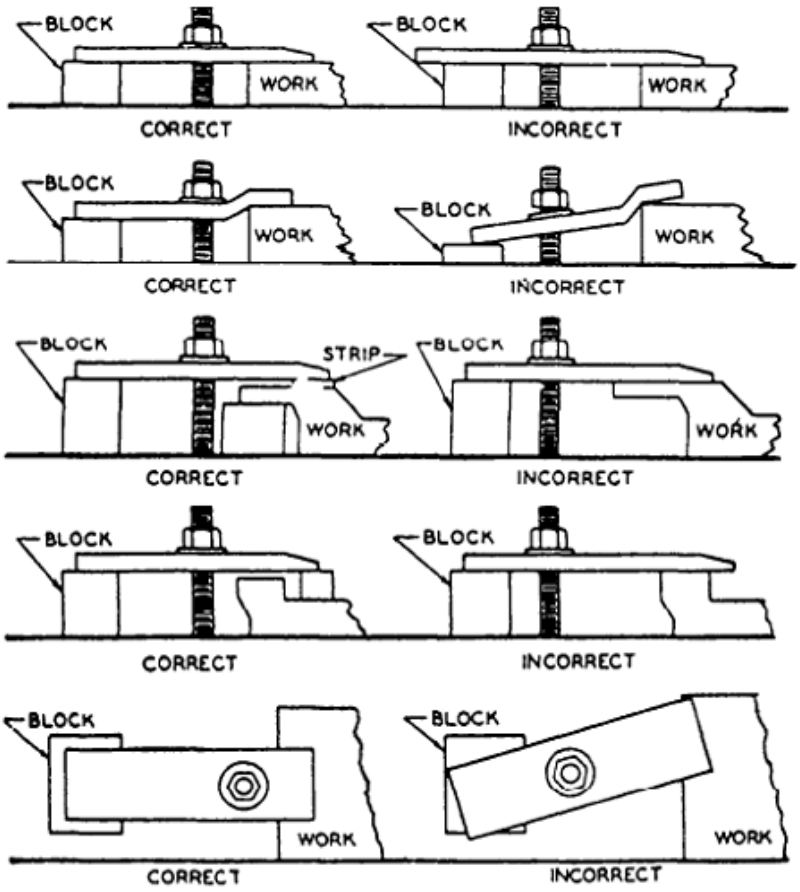


Figure 2.13. Correct and incorrect clamp applications.

2.5. Determining cutting parameters

2.5.1. Operating conditions in a Shaping Machine

The *cutting conditions* in planing and shaping are illustrated in the figure. Only the shaping operation is portrayed but the cutting conditions are essentially the same and for planing:

Cutting velocity V in planing is linear and constant along the cutting path.

In shaping, the picture is more complicated. The cutting tool is held in the tool post mounted in the ram, which reciprocates over the work with a forward stroke, cutting at velocity V and a quick return stroke at higher velocity. The cutting velocity is therefore not constant along the cutting path. It increases from zero to maximum in the beginning of the stroke and gradually decreases to zero at the end of the stroke. The cutting speed V is assumed to be twice the average forwarded ram velocity.

Feed f in planing and shaping is in mm per stroke and is at right angles to the cutting direction.

Depth of cut d is defined as usual as the distance between the work and machined surfaces.

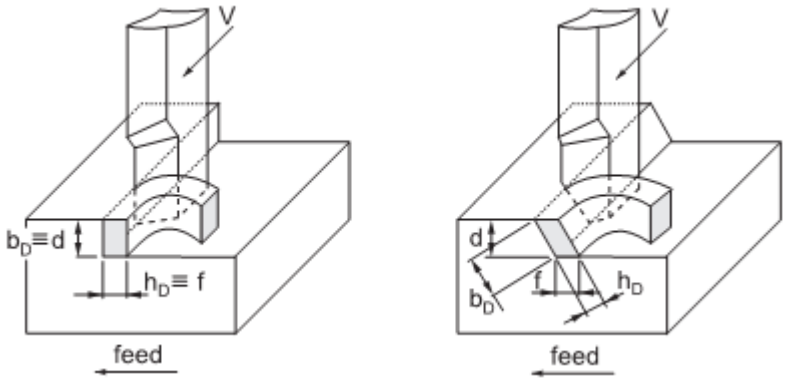


Figure 2.14. Cutting conditions in orthogonal (Left) and oblique (Right) shaping.

Cutting Action of a Shaper

On a shaper, the work is stationary and the single point cutting tool moves against it, ***Figure 2.15.*** While primarily used to machine flat surfaces, a skillful machinist can manipulate it to cut curved and irregular shapes, slots, grooves, and keyways. Work is usually mounted in a vise, ***Figure 2.16***.

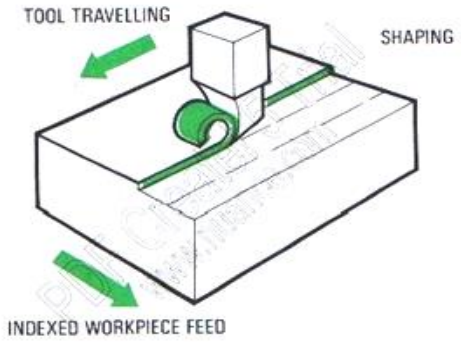


Figure 2.15. Diagram shows how shaper operates. Work is stationary and cutting tool moves against it.

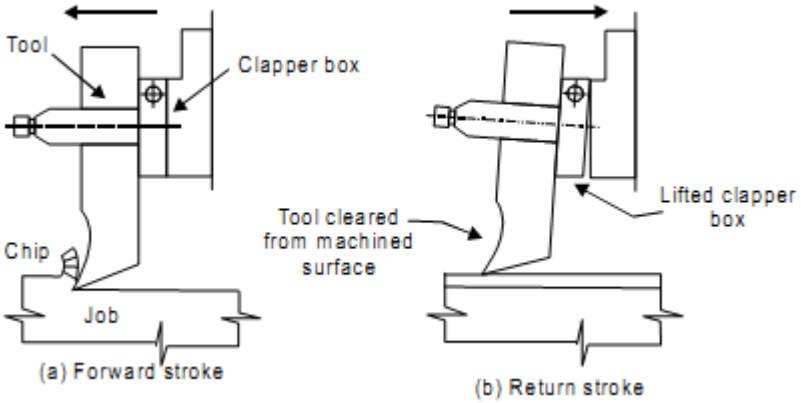


Figure 2.16. The cutting action and functioning of clamper box in a shaper.

In a shaper a single point cutting tool reciprocates over the stationary workpiece. The tool is held in the tool post of the reciprocating ram and performs the cutting operation during its forward stroke. It may be noted that during the backward stroke of the ram, the tool does not remove material from the workpiece. Both these strokes (i.e., forward and backward strokes) form one working cycle of the shaper.

2.5.2. Speeds and Feeds

You will set up the shaper to cut a certain material similar to the way you set up other machine tools, such as drill presses and lathes. First, determine the approximate required cutting speed, then determine and set the necessary machine speed to produce your desired cutting speed. On all of the machine tools we discussed in the previous chapters, cutting speed was directly related to the speed (rpm) of the machine's spindle. You could determine what spindle rpm to set by using one formula for all brands of a particular type of machine. The setup for a shaper is slightly different. You still relate cutting speed to machine speed through a formula, but the formula depends on the brand of machine that you operate. This is because some manufacturers use a slightly different formula to compute cutting speed than others. To determine the correct formula for your machine, consult the operator's manual provided by the manufacturer.

Speeds and feeds are dependent on many factors that control the efficiency of the shaper use. Factors such as ***depth of cut, amount of feed, material to be machined,*** **and** ***type of cutting tool*** control the speeds and feeds for machining. Table 2.1. gives recommended shaper speeds and feeds.

When speeds and feeds are selected, the following factors must be considered:

- The type of material being cut
- The type of cut (roughing or finishing)
- The type of cutting tool used
- The type of surface finish required
- Vertical feed on a shaper may be used for machining vertical or angular surfaces, by the down feed screw on the tool head or automatically by the power down feed.
- The power feed is attached to the down feed screw by a bevel gear drive, and on the return stoke of the ram, the feed mechanism indexes the amount of vertical feed per cut.
- Feeds used for flat or angular surfaces should always be operated on the return stroke

The cutting speeds and related machine speeds for a Cincinnati shaper. When you determine the speed of the shaper required to produce a particular cutting speed, you must account for the shaper's reciprocating action. This is because the tool only cuts on the forward stroke of the ram. In most shapers the time required for the cutting stroke is 1 ½ times that required for the return stroke. This means that in any one cycle of ram action the cutting stroke consumes 3/5 of the time and the return stroke 2/5 of the time. The formula used to determine machine strokes contains a constant that accounts for the time consumed by the cutting stroke. To determine a cutting stroke

value to set on the shaper speed indicator, first select a recommended cutting speed for the material you plan to shape from a chart such as the one shown in table 2.1.

Table 2.1. Shaper speeds and feeds

	Machine steel				**Tool steel**				**Cast iron**				**Brass**			
	Speed per minute		**Feed**		**Speed per minute**		**Feed**		**Speed per minute**		**Feed**		**Speed per minute**		**Feed**	
Cutting tool	Ft	m	in.	mm	ft	M	in.	mm	ft	m	in.	mm	ft	m	in.	mm
H.S.S.	80	24	0.010	0.25	50	15	0.015	0.38	60	18	0.020	051	160	48	0.010	0.25
Carbide	150	46	0.010	0.25	150	46	0.012	0.30	100	30	0.012	0.30	300	92	0.01	0.38

Next, determine the ram stroke speed by using the following formula (remember, your machine may require a slightly different formula):

$$SPM = CS / (0.14 \times LOS)$$

Where:

spm = strokes of the ram per minutes
Cs = cutting speed in feet per minute
Los = length of stroke in inches
0.14 = constant that accountants for partitioned ram cycle time and that converts inches to feet

Then, set the number of strokes per minute on the shaper by using the gear shift lever. A speed (strokes) indicator plate shows the positions of the lever for a variety of speeds. Take a few trial cuts and adjust the ram speed as necessary until you obtain the desired cut on the work. If after you have adjusted the ram speed, you want to know the exact cutting speed of the tool, use the following formula:

$$CS = SPM / (LOS \times 0.14)$$

The speed of the shaper is regulated by the gear shift lever. The change gear box, located on the operator's side of the shaper, lets you change the speed of the ram and cutting tool according to the length of the work and the hardness of the metal. When the driving gear is at a constant speed, the ram will make the same number of strokes per minute regardless of whether the stroke is 4 inches or 12 inches.

Therefore, to maintain the same cutting speed, the cutting tool must make three times as many strokes for the 4-inch cut as it does for the 12-inch cut. Horizontal feed rates of up to approximately 0.170 inch per stroke are available on most shapers. There are no hard and fast rules for selecting a specific feed rate; you must rely on experience and common sense.

Generally, to make roughing cuts on rigidly held work, set the feed as heavy as the machine will allow. For less rigid setups and for finishing, use light feeds and small depths of cut. It is best to start with a relatively light feed and increase it until you reach a desirable feed rate.

A. Cutting Speed

It is defined as the average linear speed of the tool during the cutting stroke in m/min, which depends on number of ram strokes (or ram cycles) per minute and length of the stroke. Cutting speeds for materials are expressed in either feet per minute (ft/min) or meters per minute (m/min)

Shaper speed depends up on three factors:

1. The type of material being cut
2. Its length and
3. The type of cutting tool used

Cutting Speed (u) = [NL (1 + m)] / 1000 (in m/min) ……. (2.1)

Where

N = the number of double strokes or cycle of the ram/min (one double or full stroke comprises one cutting and one return stroke)
L = length of the ram stroke, in mm
m = return stroke time / cutting stroke time

Inch Speed Calculations

To obtain number of strokes per minutes (N),

N = (CS x 7) / L ……. (2.2)

Where, N = number of stroke per minute
L = length of the stroke plus 1 in for tool clearance
CS = cutting speed of metal in feet per minutes
7 = constant for shaper speeds

- Since the recommended cutting speeds are stated in feet per minute and the length of the cutting stroke in inches, it is necessary to change:
  - feet by multiplying by 1/12
  - divide the above calculation by 3/5 (since the cutting stroke takes up 3/5 of the cycle) or multiply by 5/3
  - Instead of multiplying by 1/12 and then by 5/3, it is easier to use 0.14 or 1/7.
- Therefore, to calculate stokes per minute, divide the cutting speed of the metal by the length of the stroke times 0.14 or 1/7

Thus; N = CS/Lx 0.14 or N = CS/Lx1/7

Example:

1. How many stroke per minute should the ram be set to shape a piece of machine steel 9 in long?

Solution:

N = (CS x 7) / L = (80 x 7) / (9 +1) = 560 / 10 = 56 strokes/minute

2. Find the number of strokes per minute for a shaper to machine a piece of 11 in long cast iron at 60 ft/minute.

Solution:

N = (CS x 7) / L = (60 x 7) / (11 +1) = 420 / 12 = 35 strokes/minute

Note: L is always the length of the work plus 1 in for tool clearance

Metric Speed Calculations

When shaping a work piece with metric dimensions, set the length of stroke to 25mm longer than the work piece, to allow for clearance at each end of the stroke. The number of strokes per minute is calculated as follows:

Strokes per minute (N) = [CS (in meters) / L (in meters)] x (3/5) or

N = [CS (in meters) / L (in meters)] x 0.6

N = [CS / L] x 0.6

Where, 3/5 = Ratio of forward to return stroke

The length of the work is usually given in millimetres; therefore, divide the length plus the tool clearance by 1000 to bring it to meters.

Example:

1. How many strokes per minute will be required to machine a 330 mm long piece of tool steel? (CS = 15 m/minute)

Solution

Length of stroke (L) = Length of the work + Clearance = 330 mm + 25 mm = 355 mm = 0.36 m

Strokes per minute (N) = [CS (in meters) / L (in meters)] x (3/5 or 0.6)

N = [CS / L] x 0.6

= [15 / 0.36] x 0.6

= 41.666* x 0.6

= 25 stroke per minute

Note: When shaping a work piece with metric dimensions, set the length of stroke to 25mm longer than the work piece

Exercise:

In a shaper work, the length of the stroke is 200mm, the number of double strokes /min is 30 and the ratio of return time to cutting time is 2:3. Find the cutting speed.

Ans: 10m/min

B. Shaper Feed Mechanism

- Shaper feed is defined as the distance the work is moved sideways toward the cutting tool for each forward, stroke of the ram.
- Feed f is the relative motion of the work piece in a direction perpendicular to the axis of the reciprocation of the arm.
- In shaper, feed is normally given to the work piece and can be automatic or manual.
- It is expressed in mm/double stroke or simply mm/stroke because no cutting is done in return stroke

When horizontal surfaces are being machined, the table upon which the work is mounted feeds the work toward the cutting tool automatically on the return stroke of the ram. When vertical feeds are required, the feed is controlled by turning the down feed screw handle by hand or automatically if the shaper is equipped with an automatic down feed mechanism, on each return stroke of the ram.

On hydraulic shapers, the feed direction and the amount of feed are regulated by control and reversing valves. The feed is driven by a gear and a rack which are controlled by a hydraulic system. Feeds can be increased or decreased while the machine is running by adjustment of the valves.

Setting the rate of feed

- The rotating driving wheel sets the pawl into reciprocating motion by means of the connecting rod and crank pin.
- The pawl carries the ratchet with it in one direction, and moves the table.
- ***Crank pin moved outwards***: Greater distance travelled by the pawl and ratchet result in a **higher feed rate.**
- ***Crank pin drawn inwards*** - smaller distance travelled by the pawl and ratchet results in lower **feed rate**.

To Engage or Disengage the Table Feed

1. Move the cutting tool clear of the work.
2. Turn the pawl knob until the pawl engages in the sprocket wheel, as in *Figure 2.17*.
3. Start the shaper.

4. Check the position of the connecting rod in the T-slot in gear B to see that the feed operates on the return stroke of the ram. *(Note: The feed should operate only on the return stroke of the ram).*
5. To set the amount of feed, adjust the connecting rod off center at B so that the pawl will move (index) two or more teeth on the sprocket wheel when the ram is on its *return* stroke.
6. To disengage the feed, raise the pawl knob and turn the pawl 90° to prevent the pawl from entering the teeth in the sprocket wheel.

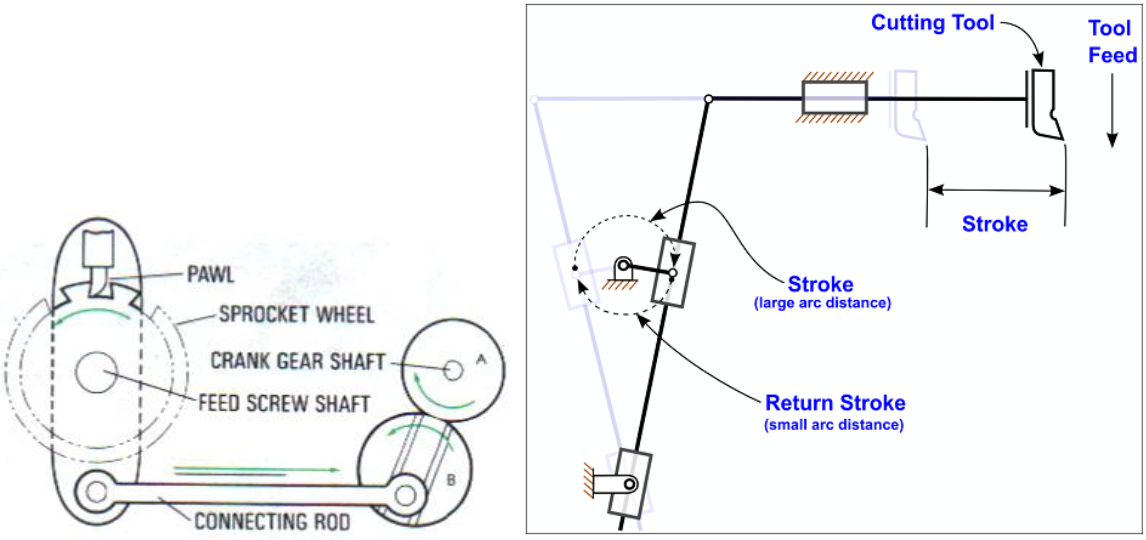


Figure 2.17. Engaging and Disengaging the Table Feed

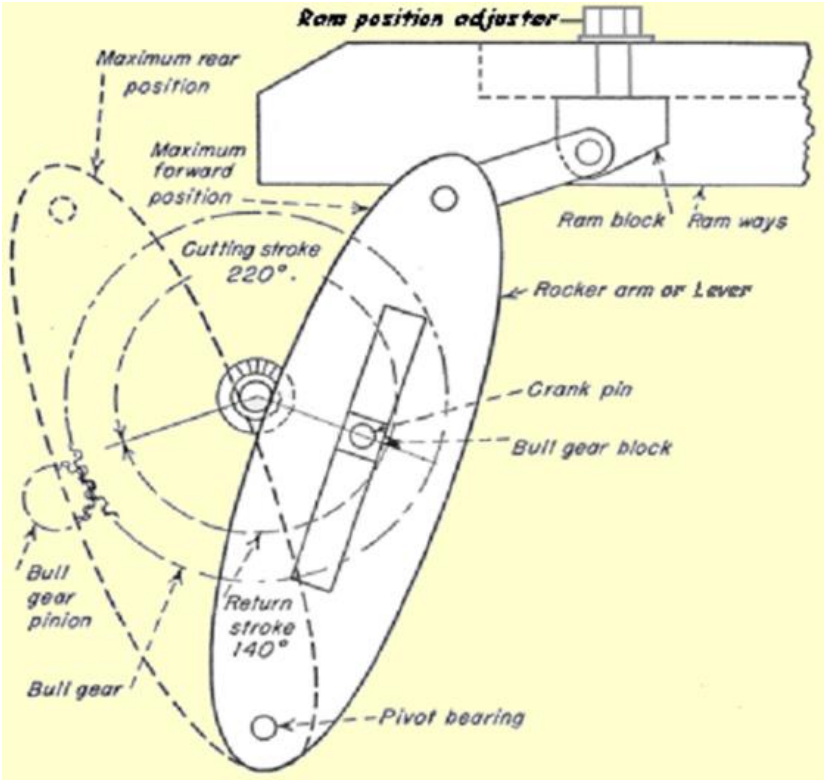
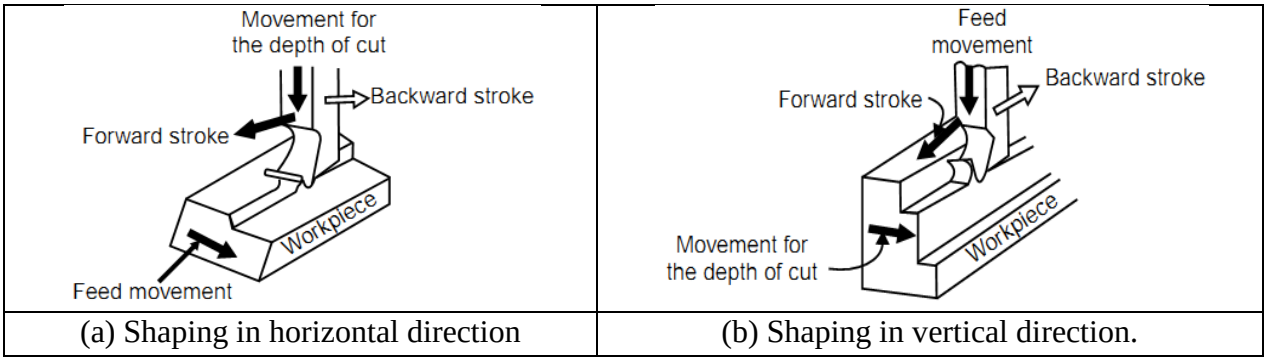


Figure 2.18. The shaper table feed mechanism.

C. Depth of cut

Depth of cut d is the thickness of the material removed in one cut, in mm. For shaping in horizontal direction, as shown in Figure 2.19. (a), the clamped workpiece is fed against the reciprocating tool after every cutting cycle. The depth of cut is adjusted by moving the tool downward towards the workpiece. For shaping in vertical direction, as shown in Figure 2.19. (b). The tool is fed vertically towards the workpiece after every cutting cycle. The depth of cut is adjusted by moving the workpiece sideways.



(a) Shaping in horizontal direction | (b) Shaping in vertical direction.

Figure 2.19. Working Principle and Operation of a Shaper

D. Length of Cut

Setting the shaper stroke length

To set the shaper stroke length

- Measure the length of the work piece and add 25 mm to the length
- Start the shaper and stop it when the ram is at the back of the stroke
- Loosen the stroke regulator lock nut
- Adjust to the length required by turning the stroke regulator screw
- Tighten the stroke regulator lock cut

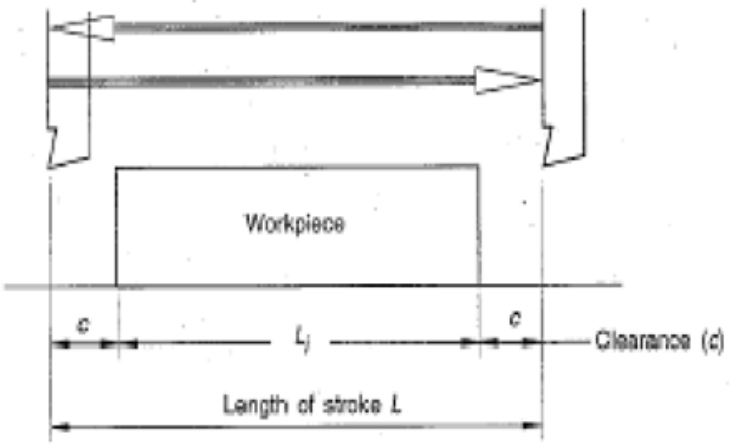


Figure 2.20. Length of stroke and length of work piece

- Stroke length = L
  - Lj = Job of length
  - C = Clearance
- L = Lj + 2XC …….. (2.3)

Changing the stroke length

If the crank pin is drawn away from the center of the wheel, it describes a crank circle of greater radius, and the rocker arm swings through a greater distance, the stroke becomes longer

- Analogously, if it is drawn towards the center of the wheel, a shorter stroke results.
- *Changing the stroke position must be set to match the position of the work piece.*

Setting the Shaper Stroke

The shaper stroke must be set to suit the length of each work piece, and also the position where it is held in a vice, on the table, or other work-holding device. If the shaper stroke is longer than necessary, valuable time will be wasted since it will take longer to complete the job. Since the setting up of work in a shaper vice is exactly the same as that for a milling machine vice.

To Set the Length of the Shaper Stroke

1. Mount the work in the shaper vice (Figure 2.21.)



Figure 2.21. Use paper feelers between the work and parallels when setting work in vice. (Courtesy Kostel Enterprises Ltd.)

2. Measure the length of the work and add 1 in. (25.4 mm) for tool clearance (1/2 in. or 12.7 mm at each end of the stroke).
3. Use the start-stop or inching button to jog the motor until the ram is at the extreme back end of the stroke *or* Place the crank on the stroke regulator shaft and turn it until the ram is at the back end of the stroke (Figure 2.22.)

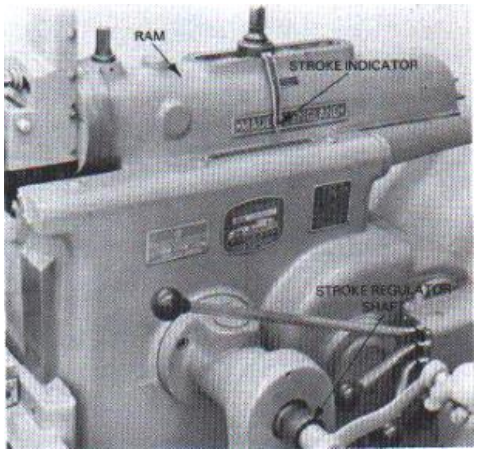


Figure 2.22. Setting the ram to the back end of the stroke. (Courtesy Kostel Enterprises Ltd.)

4. Loosen the stroke-regulator lock nut about one-half turn (Figure 2.23.).



Figure 2.23. To loosen the locknut, hold it firmly and turn the crank clockwise. (Courtesy Kostel Enterprises Ltd.)

5. Turn the stroke regulator shaft until the stroke indicator is at the desired length of stroke.
6. Tighten the stroke-regulator lock nut.

To Set the Position of the Shaper Stroke

Before setting the position of the shaper stroke, the length of stroke must be first set as in the previous operation. The ram must then be adjusted so that the cutting tool will machine the full length of the piece. *(Note: Always be sure that the ram is at the back end of the stroke before setting the length or position).*

1. Set the length of the stroke as in the previous operation.
2. Be sure that the ram is at the extreme back end of the stroke.
3. Loosen the ram lock or clamp (Figure 2.24.).

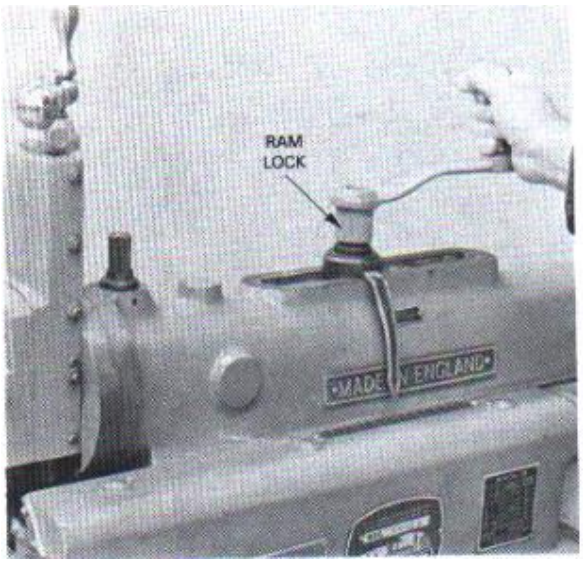


Figure 2.24. To loosen the ram lock, turn it counter clockwise. (Courtesy Kostel Enterprises Ltd.)

4. Pull the tool head and ram forward until the tool bit is within $^{1}/2$ in. (12.7 mm) of the work (Figure 2.25.). Or if the ram is equipped with an adjusting screw, turn it until the tool bit is within 1/2 in. (12.7 mm) of the work.

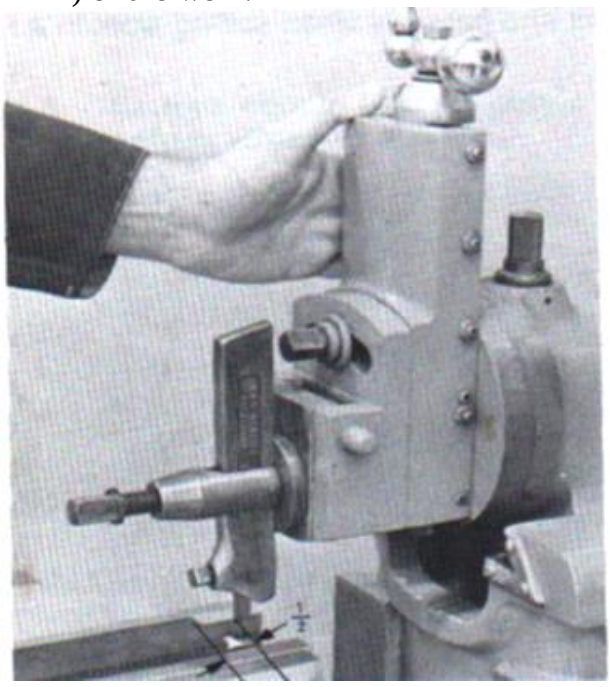


Figure 2.25. The ram may be moved by hand to bring the tool bit within ½ inch (12.7 mm) of the work piece.

5. Tighten the ram lock or clamp.
6. With the cutting tool clear of the work, start the machine and see that the toolbit clears each end of the work by about 1/2 in. (12.7 mm).

2.5.3. Machining Time

From the cutting speed, we can find that the time required to complete one double stroke is given by:

$t = [L \times (1 + m)] / (1000 \times u)$ (in minutes) …….. (2.4)

with a feed of f mm/ double stroke, number of double strokes required to machine a surface of width w will be:

$N_s = w / f$ …….. (2.5)

Hence, total time for machining the surface will be:

$t = [L * w * (1 + m)] / (1000 * u * f)$ (in minutes) …….. (2.6)

or

In terms of ram strokes N, total time for machining the surface is given by:

$t_s = w / Nf$ (in minutes) …….. (2.7)

2.5.4. Material removal rate

$MRR = fdNL(1 + m)$ …….. (2.8)

Where d is depth of cut in mm,
f in mm/stroke,
N in strokes/min, and
L is length of stroke in mm

Example 7.1 **Find the machining time required for machining a surface 600 × 800 mm on a shaping machine. Assume, cutting speed as 8 m/min. The return-to-cutting time ratio is 1 : 4, and the feed is 2 mm/double stroke. The clearance at each end is 70 mm.**

Solution: Given

$L_j = 600$ mm, $w = 800$ mm, $v = 8$ m/min,
$m = ¼$, $f = 2$ mm/stroke, $c = 70$ mm.

From Eq. (7.2), we get

Length of stroke $L = 600 + 2 \times 70 = 740$ mm

Substituting all the values in Eq. (7.5), we get

$$t = \frac{740 \times 800 \times (1 + 0.25)}{1000 \times 8 \times 2} = 46.25 \text{ min.}$$ **Ans.**

Exercise:

The 400mmX250mm face of cast iron block of size 400mmX250mmX 100mm is to be rough machined using HSS tool on a conventional crank shaper. Estimate the machining time assuming an average cutting speed of 20m/min and a feed of 0.2 mm/stroke. The cutting time to return time ratio is given to be 1.5 and the ram cycles available on the shapers are 28,40,60 and 90 per minute.

Ans: choosing 28 strokes/min, time=44.65 min

The suggested cutting speed for a given tool –work piece combination on a shaper is 25m/min. Two 300X200 mm surfaces of a cast iron block 400X 300x 200 mm are to be rough machined on a shaper using HSS tool. A feed of 0.5mm/stroke may be assumed for this cutting operation. If the set up time is 10 minutes per surface and the labor and overhead charges are Rs 150 per hour, find the cost of machining 500 blocks. Assume return to cutting time ratio as 1:2.

Ans: neglecting clearance, taking L=300mm and using 56 strokes/min, Cost= Rs 51,775.

Self-check - 2

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.** (1 point for each)

1. In shaping, the cutting tool reciprocates over the work with a constant cutting velocity along the cutting path.
2. Speeds and feeds are dependent on factors that control the efficiency of the shaper use

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives. (1 point for each)

1. Finishing is the operation best done by
   (a) Milling machine (b) Shaper machine
   (c) Planar machine (d) Grinding
2. The shaping process is very slow but it is mostly used because of
   (a) Easy of operation (b) Short set up time
   (c) Inexpensive tooling (d) All of above
3. The shaper is specified by
   (a) Maximum height of machine (b) Maximum length of stroke
   (c) Weight of machine (d) All of above
4. In shaper the ram should move
   (a) Slower during return stroke (b) Faster during return stroke
   (c) At the same speed during return stroke (d) All of above

Part III: Marching - Instructions: For the following questions matching from **"B" to "A" column** (1 point for each)

No.	"A" Column	"B" Column
_____ 1.	Cutting speed	A. The thickness of the material removed in one cut
_____ 2.	Depth of cut	B. The distance the work is moved sideways toward the cutting tool for each forward stroke of the ram
_____ 3.	Shaper feed	C. The average linear speed of the tool during the cutting stroke

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers. (2 points)

1. List dawn the main parts of shaper and its function
2. Explain the Principle of the crank-type shaper
3. Explain the Principle of Hydraulic shaper
4. What factors be considered when speeds and feeds of shaper machine are selected?

ANSWER SHEET

True or False

1. False
2. True

Multiple Choice

1. (d)
2. (d)
3. (b)
4. (b)

Marching

1. C
2. A
3. B

Short Answer Questions

1.
2.
3.
4.

Unit Three: Perform precision shaping operations
This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics: • Precision shaping operations This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Carry out precision shaping operations of flat surfaces, shoulders, slots, keyways, angles and dovetails.

3. Carrying out precision shaping operations

The following discussion explains basically how the operation of a shaper differs from the operation of other machine tools.

3.1. Aligning the Shaper Vice

Most work machined in a shaper is held in a vice bolted to the table. Since the setup of work in a shaper vice and a vertical mill vice is exactly the same, this information will not be repeated in this unit. Whenever this information is required, reference will be made to the vertical milling machine units which contain detailed information.

The body of the vice can be swivelled on a base plate to any angular setting required. When the work must be machined parallel or at right angles to the direction of the cut, the vice jaw must be aligned. To accurately align the vice, a dial indicator is attached to the tool head of the shaper and passed over the entire length of the solid jaw. With this method, a vice can be aligned to within 0.001 in. (0.02 mm) accuracy.

(Note: Always adjust the vice away from and not toward the indicator plunger.)

To align the shaper vice parallel (Figure 3.1.) or at 90° to the ram travel (Figure 3.2.).

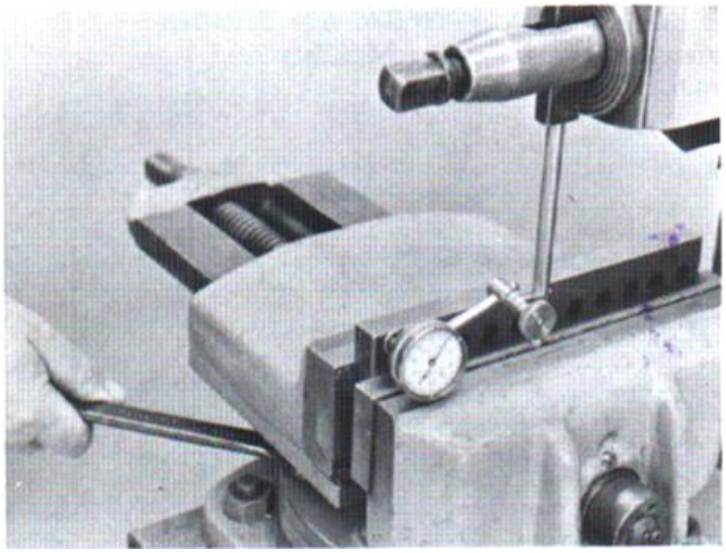


Figure 3.1. Aligning the vice parallel to the ram travel. (Courtesy Kostel Enterprises Ltd.)

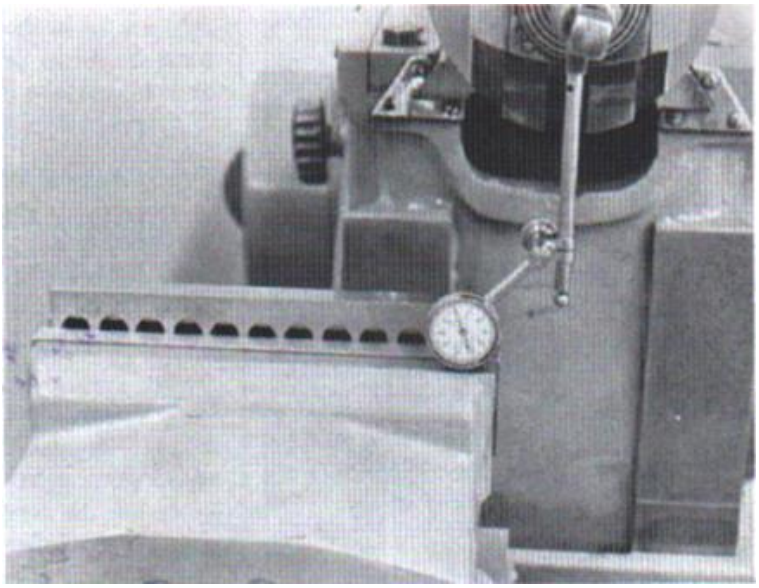


Figure 3.2. Aligning the vice at 90° to the ram travel. (Courtesy Kostel Enterprises Ltd.)

3.2. To Mount Work in a Shaper Vice

1. Remove all burrs from the work- piece (Figure 3.5.).
2. Clean the work and the vice thoroughly.
3. Select a set of parallels large enough to raise the work about' in. (6.35 mm) above the vice jaws.
4. Set the work on the parallels in the center of the vice. *(Note: Always grip work in the center to prevent springing or twisting the vice).*
5. Place a short paper feeler between each corner of the work and the parallels

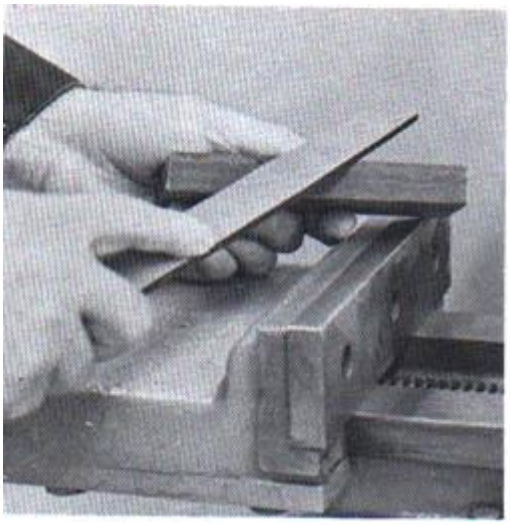


Figure 3.5. Remove all burrs from the work piece before setting work in vice. (Courtesy Kostel Enterprises Ltd.)

6. Tighten the vice securely. If the vice is not tightened securely, when the work is tapped down, it will hit the parallels and bounce up.
7. Tap the work down onto the parallels with a soft-faced hammer alternating the hammer blows between each end of the work.
8. Tap each corner of the work down until all the paper feelers are tight.
9. *Do not* retighten the vice after the work has been tapped down because the work will be forced up and off the parallels during the tightening process.

3.3. Shaping a Rectangular Block

Shaping a Flat Surface:

Most work machined in a shaper is held in a vice. After the work is properly set up in the vice, the cutting tool must be set to the surface of the work and the surface is then machined.

Accurately machined rectangular block has square corners and opposite surfaces that are parallel to each other. In this discussion, faces are the surfaces of the block that have the largest surface area; the ends are the surfaces that limit the length of the block; and the sides are the surfaces that limit the width of the block.

You can machine a rectangular block in four setups if you use a shaper vice. Machine one face and an end in the first setup. Machine the opposite face and end in the second setup. Then, machine the sides in two similar but separate setups. Align the vies jaws at right angles to the ram in both setups.

To machine a rectangular block from a rough casting, use the following sequence of operations:

1. Clamp the casting in the vice so a face is horizontally level and slightly above the top of the vies jaws. Allow one end to extend out of the side of the vice jaws enough so you can take a cut on the end without unclamping the casting. Now feed the cutting tool down to the required depth and take a horizontal cut across the face. After you have machined the face, readjust the cutting tool so it will cut across the surface of the end that extends from the vice.
2. To machine the second face and end, turn the block over and set the previously machined face on parallels (similar to the method used in step 1). Insert small strips of paper between each corner of the block and the parallels.
3. To machine a side, open the vice jaws so the jaws can be clamped on the ends of the block. Now set the block on parallels in the vice with the side extending out of the jaws enough to permit a cut using the down feed mechanism. Adjust the ram for length of stroke and for position to machine the side and make the cut.
4. Set up and machine the other side as described in step 3.

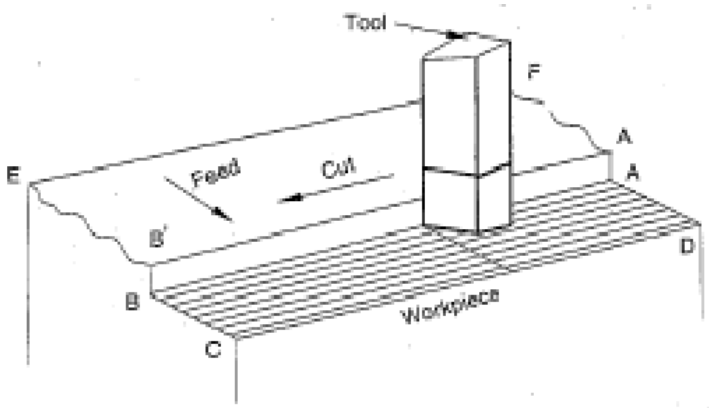


Figure 3.2. Process of producing a flat surface.

3.4. Shaping Angular Surfaces

You may use one of two methods to machine angular surfaces. For steep angles, such as on V-blocks, mount the work horizontally and swivel the tool head to the desired angle. For small angles of taper, such as on wedges, mount the work on the table at the desired angle from the horizontal, or you can tilt the table if the shaper has a universal table. To machine a steep angle using the tool head swivelled to the proper angle, use the following sequence of operations:

1. Set up the work as you would to machine a flat surface parallel with the table.
2. Swivel the tool head (Figure 3.3.) to the required angle. (Swivel the clapper box in the opposite direction.)
3. Start the machine and, using the manual feed wheel on the tool head, feed the tool down across the work piece. Use the horizontal feed control to feed the work into the tool and to control the depth of cut (thickness of the chip). (Because the tool is fed manually, be careful to feed the tool toward the work only during the return stroke.)
4. Set up and machine the other side as described in step 3.

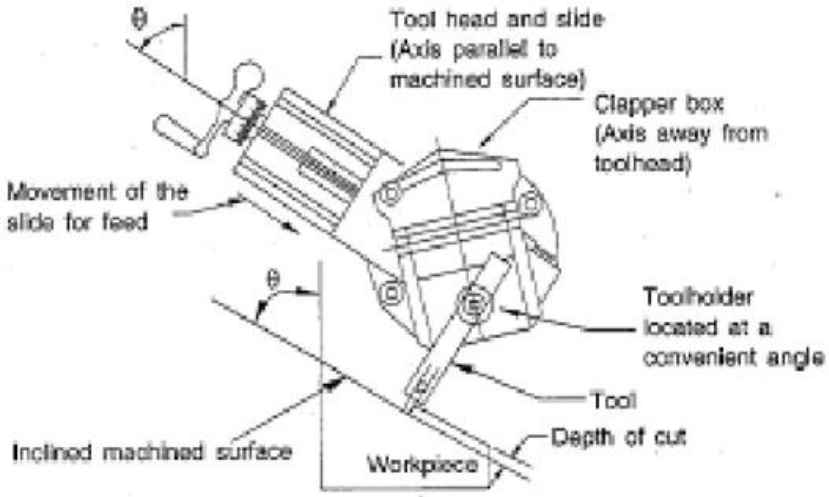


Figure 3.3. Machining of inclined surface on shaping machine

3.5. Shaping Keyways in Shafts

Occasionally you may use a shaper to cut a keyway in a shaft. Normally, you will lay out the length and width of the keyway on the circumference of the shaft. A centreline laid out along the length of the shaft and across the end of the shaft will make the setup easier (Figure 3.4., view A). Figure 3.4. also shows holes of the same diameter as the keyway width and slightly deeper than the key drilled into the shaft. These holes are required to provide tool clearance at the beginning and end of the cutting stroke. The holes shown in figure 3.4. are located to cut a blind keyway (not ending at the end of a shaft). If the keyway extends to the end of the shaft, only one hole is necessary. To cut a keyway in a shaft, use the following sequence of operations:

1. Lay out the centre line, the keyway width, and the clearance hole centres, as shown in view A of figure 3.4. Drill the clearance holes.
2. Position the shaft in the shaper vice or on the worktable so that it is parallel to the ram. Use a machinist's square to check the centreline on the end of the shaft to be sure it is perpendicular to the surface of the worktable. This ensures that the keyway layout is exactly cantered at the upper most height of the shaft and that the keyway is cantered on the centrelines of the shaft.
3. Adjust the stroke and the position of the ram so the forward stroke of the cutting tool ends at the centre of the clearance hole. (If you are cutting a blind keyway, be sure the cutting tool has enough clearance at the end of the return stroke so the tool will remain in the keyway slot.) (See view B of Figure 3.4.)
4. Position the work under the cutting tool so that the tool's canter is aligned with the centreline of the keyway. (If the keyway is more than ½ inch wide, cut a slot down the centre and shave each side of the slot until you get the proper width.
5. Start the shaper and use the tool head slide to feed the tool down to the depth required, as shown on the graduated collar.

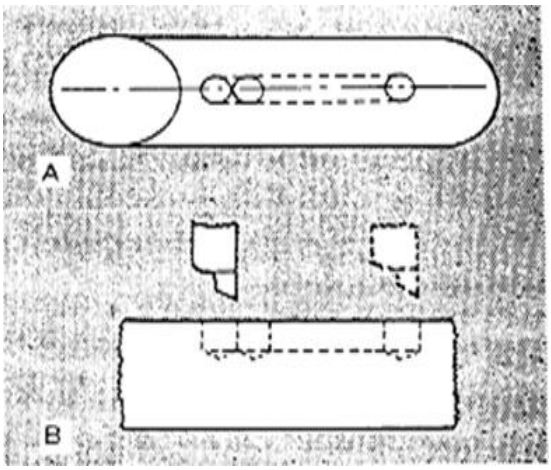


Figure 3.4. Cutting a keyway in the middle of shaft.

3.6. Shaping an Internal Keyway

To cut an internal keyway in a gear, you will have to use extension tools. These tools lack the rigidity of external tools, and the cutting point will tend to spring away from the work unless you take steps to compensate. The keyway must be in line with the axis of the gear. Test the alignment with a dial indicator by taking a reading across the face of the gear. Swivel the vice slightly to correct the alignment if necessary. The bar of the square-nose tool holder should not extend further than necessary from the shank; otherwise, the bar will have too much spring and will allow the tool to be forced out of the cut. The extension tool holder should extend as far as practical below the clapper block, rather than in the position shown by the dotted lines in view A of figure 3.5. The pressure angle associated with the tool holder in the upper position may cause the pressure of the cut to open the clapper block slightly and allow the tool to leave the cut. In the lower position, the pressure angle is nearly vertical and prevents the clapper block from opening. Another method to prevent the clapper block from opening is to mount the tool in an inverted position. With the cutting tool set up as in view A of figure 3.5, canter the tool within the layout lines in the usual manner, and make the cut to the proper depth while feeding the tool head down by hand. If you mount the tool in an inverted position, canter the tool within the layout lines at the top of the hole, and make the cut by feeding the tool head up ward.

Figure 3.5., view B, shows the relative depths to which external and internal keyways are cut to produce the greatest strength. When you cut a keyway in the gear, set the down feed micrometer collar to zero at the point where the cutting tool first touches the edge of the hole. First, remove the crown, X, from the shaft to produce a flat whose width is equal to the width of the key. Then, make a cut in the shaft to depth 2. The distance of Y plus Z is equal to the height of the key that is to lock the two parts together.

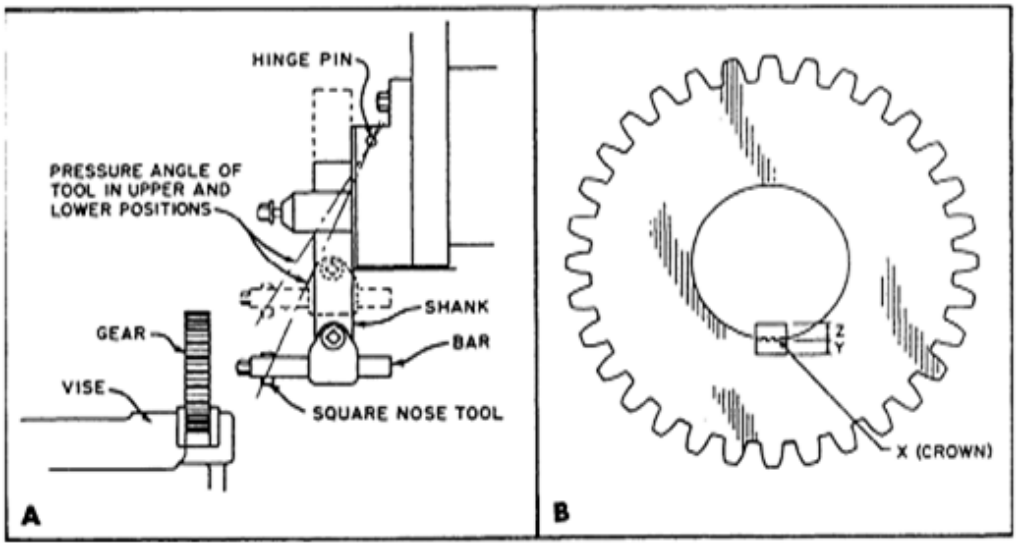


Figure 3.5. Internal keyway: A. Shaping an internal keyway in a gear. B. Depth of keyways.

3.7. Shaping Irregular Surfaces

To machine irregular surfaces, use form ground tools and feed the cutting tool vertically by hand while using power feed to move the work horizontally. A gear rack is an example of work you might shape by using form tools. You can use the tool head feed to shape work such as concave and convex surfaces.

To machine irregular surfaces, you have to pay close attention because you control the cutting tool manually. Also, you should lay out the job before you machine it to provide reference lines. You also should take roughing cuts to remove excess material to within 1/16 inch of the layout lines. You can cut rack teeth on a shaper as well as on a planer or a milling machine. During the machining operation, you may either hold the work in the vice or clamp it directly to the worktable. After you mount and position the work, use a roughing tool to rough out the tooth space in the form of a plain rectangular groove, and then finish it with a tool ground to the tooth's finished contour and size.

To machine a rack, use the following sequence of operations:

1. Clamp the work in the vice or to the table.
2. Position a squaring tool, which is narrower than the required tooth space, so the tool is centered on the first tooth space to be cut.
3. Set the graduated dial on the cross feed screw to zero, and use it as a guide to space the teeth.
4. Move the tool slide down until the tool just touches the work, and lock the graduated collar on the tool slide feed screw.
5. Start the machine and feed the tool slide down slightly less than the whole depth of the tooth, using the graduated collar as a guide, and rough out the first tooth space.

6. Raise the tool to clear the work and move the cross feed a distance equal to the linear pitch of the rack tooth by turning the cross feed lever. Rough out the second tooth space, and repeat this operation until all spaces are roughed out.
7. Replace the roughing tool with a tool ground to size for the desired tooth form, and align the tool.
8. Adjust the work so the tool is properly aligned with the first tooth space that you rough cut.
9. Set the graduated dial on the cross feed screw at zero and use it as a guide to space the teeth.
10. Move the tool slide down until the tool just touches the work, and lock the graduated collar on the tool slide feed screw.
11. Feed the tool slide down the whole depth of the tooth, using the graduated collar as a guide, and finish the first tooth space.
12. Raise the tool to clear the work and move the cross feed a distance equal to the linear pitch of the rack tooth by turning the cross feed lever.
13. Finish the second tooth space; then measure the thickness of the tooth with the gear tooth vernier caliper. Adjust the tool slide to compensate for any variation indicated by this measurement.
14. Repeat the process of indexing and cutting until you have finished all of the teeth.

Use the following procedure to machine irregular surfaces that have Convex and/or Concave radii.

1. On one end of the work, lay out the contour of the finished job.
2. When you shape to a scribed line, as shown in figure 3.6., it is good practice to rough cut to within 1/16 inch of the line. You can do this by making a series of horizontal cuts using automatic feed and removing excess stock.
3. Use a left-hand cutting tool to remove stock on the right side of the work and a right-hand cutting tool to remove stock on the left side of the work.
4. When 1/16 inch of metal remains above the scribed line, take a file and bevel the edge to the line. This will eliminate tearing of the line by the breaking of the chip.
5. Starting at the right-hand side of the work, set the automatic feed so the horizontal travel is rather slow.
6. Feed the tool vertically by hand to take finishing cuts and produce a smooth contoured surface.

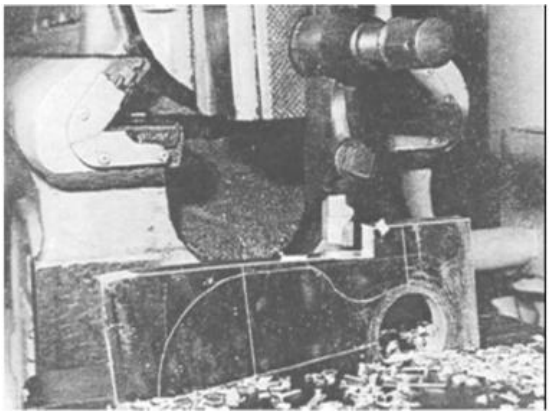


Figure 3.6. Shaping irregular surfaces.

Self-check - 3

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.**

1. Most work machined in a shaper is held in a vice bolted to the table.
2. Accurately machined rectangular block has square corners and opposite surfaces that are parallel to each other.

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives.

1. The planer is differs from shaper mainly as
   (a) The table is stationary while the tool is moving
   (b) The table is moving while the tool remains stationary
   (c) Table and tool are stationary
   (d) The table is moving and the tool is also moving

2. Cutting tool used in shaper is
   (a) Single point (b) Multi point
   (c) Double point (d) None of above

3. During machining of shaper
   (a) The cutting tool is stationary (b) Both move opposite to each other
   (c) Both tool and job are in motion (d) The job is stationary

4. Stroke of ram of shaper is adjusted by
   (a) Changing the pinion (b) Changing the position of the crank pin
   (c) Changing the position of lead screw (d) None of above

Part III: Marching - Instructions: For the following questions match from **"B" to "A" column**

No.	"A" Column	"B" Column
_____ 1.	To machine angular surfaces	A. Mounting the work horizontally and swivel the tool head to the desired angle
_____ 2.	To machine small angles of taper	B. Mounting the work on a universal table and tilting at the desired angle from the horizontal
_____ 3.	To machine a rectangular block in using a shaper vice	C. Machine first one face and then the opposite face in the second setup. Then, machine the sides in two similar but separate setups.
_____ 4.	To machine irregular surfaces	D. Use form ground tools and feed the cutting tool vertically by hand while using power feed to move the work horizontally.

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers.

1. Write down the used for Shaping an Internal Keyway
2. Write down the used to machine irregular surfaces

ANSWER SHEET

True or False

1. True
2. True

Multiple Choice

1. (b)
2. (a)
3. (d)
4. (b)

Marching

1. C
2. A
3. B

Short Answer Questions

1.
2.

Operation sheet - 1

Operation Title: Testing the Work Seat for Parallelism

Instruction: To align the shaper vice perpendicular (or at 90°) to the ram travel and parallel to the ram travel.

Purpose: To seat the work piece at perpendicular and parallel to the ram travel.

Required tools and equipment:

1. Dial indicator with stand
2. Parallel bloke
3. Mallet

Precautions: Clean the vice and remove all burrs before testing a vice for parallelism.

Procedures:

Step 1. Set up the indicator as shown in Figure 3.7.

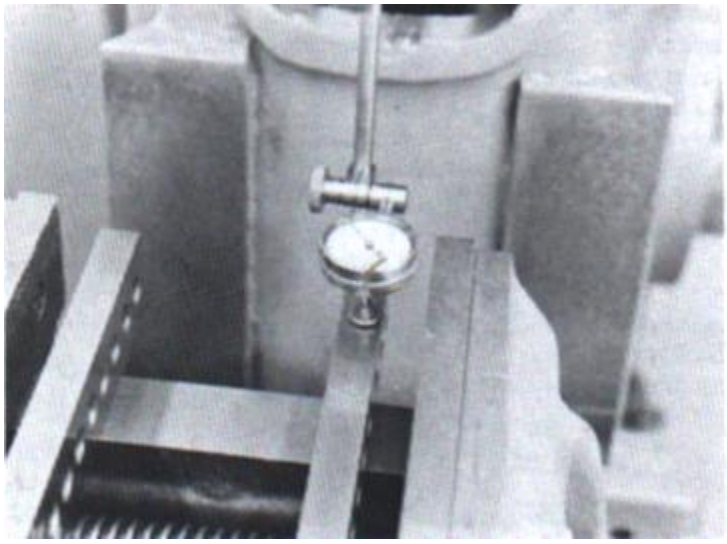


Figure 3.7. Checking the seat of the vice with an indicator and parallels. (Courtesy Kostel Enterprises Ltd.)

Step 2. Place a set of parallels on the bottom of the vice.

Step 3. Adjust the tool head until the dial indicator registers approximately one- half revolution on one parallel.

Step 4. Move the ram forward by hand for the length of the parallel and note the indicator reading.

Step 5. With the cross feed screw handle, move the vice to obtain a reading across the second parallel (Figure 3.8.).

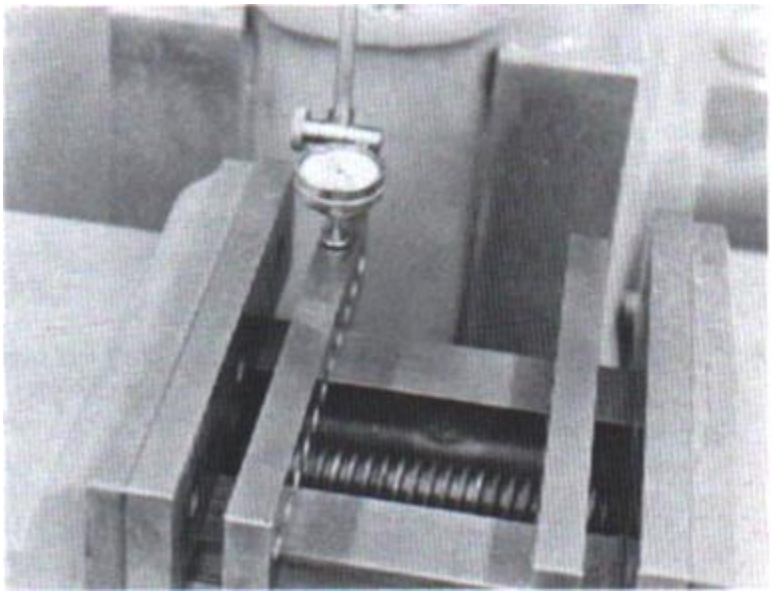


Figure 3.8. The difference between the readings on both parallels is the amount the vice is out of parallelism. (Courtesy Kostel Enterprises Ltd.)

Step 6. To correct any errors in alignment, remove the vice from the table, clean it, and remove burrs from all clamping surfaces on the vice and table.

Step 7. Remount the vice on the table and test for accuracy.

Quality criteria: A work piece aligned perpendicular (or at 90°) to the ram travel and parallel to the ram travel.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, tools, equipment, machineries and materials you are required to perform the following tasks within 10 hours, based on the given drawing.

Project Information: This project part is to perform machine operation intended for machining level II trainees and expected to observe safety precautions, determine job requirements, perform precision shaping operations of flat surfaces and to check component for conformance to specification.

Purpose: To measure the skill of trainee in reading drawing, perform Machine set-up, perform machining operation according to drawing, and surface finish.

The main tasks of the project:

The Trainee is expected to perform the following ***10 tasks*** based on the given drawing.

Task 1: Read drawings and Sketches correctly

Task 2: Prepare the working area

Task 3: Identify, select and prepare tools, equipment and materials needed to accomplish the project.

Task 4: Perform Mensuration and Calculation

Task 5: Setup the machine

Task 6: Align the Shaper Vice

Task 7: Mount a Work piece in a Shaper Vice securely

Task 8: Shaping a Rectangular Block

Task 9: Perform machining operations

Task 10: Check/ measure the product

Note:

1. All dimensions / measurements are expressed in millimeter (mm)
2. Tolerance: ± 2 mm
3. Surface finish: Ra 3.2
4. Material: Mild steel

Evaluation

- All steps were completed in the correct sequence.
- All safety precautions were followed in using the tools and equipment
- Surface finish properly done
- All dimensions, size, shape, and angles must be accurate
- Deburr all corners and angles

PROJECT 1 DRAWING

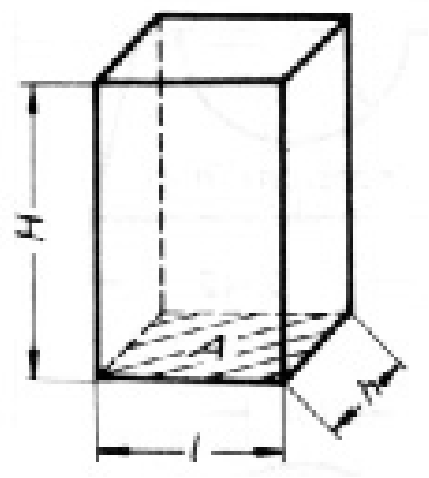


Figure 3.8.: A rectangular Prism /cube is cut from a square steel bar

Dimension:

Length = 150 mm

Height = 170 mm

Width = 120 mm

Unit Four: Perform precision Planning operations
This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics: • Precision planning operations of horizontal and vertical surfaces and angles This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Carry out precision planning operations on horizontal and vertical surfaces and angles

4. Carrying out precision planning operations

4.1. The Planer

The planer (also called planing machine) is a machine tool used to produce plane and flat surface by a single point cutting tool. It is similar to a shaper but its size is very large and is adopted for producing flat surfaces of much larger work than a shaper. The fundamental difference between a planer and shaper is that in a planer, the tool remains stationary and the work reciprocates whereas in the shaper, the work remains stationary and the tool reciprocates.



Figure 4.1. A planer.

- The machine tool for planing is a *planer*. Cutting speed is achieved by a reciprocating worktable that moves the part past the single-point cutting tool. Construction and motion capability of a planer permit much larger parts to be machined than on a shaper.

- The planer or planing machine is a machine tool, which like the shaper produces flat surfaces in horizontal, vertical or inclined plane.
- The fundamental difference is that the planer operates with an action opposite to that of the shapers, i.e., the work piece reciprocates past one or mare stationary single point cutting tools.
- Planers are meant for machining large sized work pieces, which cannot be machined by the shaping machines.

4.2. Types of Planing Machines

Some other types of planing machines include Universal planer, pit type planer and edge planer.

Planers can be classified as either open side planers or double-column planers.

The *open side planer*, also known as a *single-column planer* has a single column supporting the cross-rail on which a tool head is mounted. The configuration of the open side planer permits very wide work-parts to be machined.

A *double-column planer* has two columns, one on either side of the bed and worktable. The columns support the cross-rail on which one or more tool heads are mounted. The two columns provide a more rigid structure for the operation but limit the width of the work that can be handled.

Like a shaper, planer is used primarily to produce horizontal, vertical or inclined flat surfaces by a single point cutting tool. But it is used for machining large and heavy work-pieces that cannot be accommodated on the table of a shaper. In addition to machining large work, the planer is frequently used to machine multiple small parts held in line on the platen. Planer is mainly of two kinds namely open housing planer and double housing planer. The principle parts of the open housing planer are shown in Figure 4.2. The principle parts of the double housing planer are shown in Figure 4.3. The bigger job is fixed with help of the grooves on the base of the planer and is accurately guided as it travels back and forth. Cutting tools are held in tool heads of double housing planer and the work piece is clamped onto the worktable as shown in Figure 4.3. The worktable rides on the gin tool heads that can travel from side to side i.e., in a direction at right angle to the direction of motion of the worktable. Tool heads are mounted on a horizontal cross rail that can be moved up and down. Cutting is achieved by applying the linear primary motion to the workpiece (motion X) and feeding the tool at right angles to this motion (motion Y and Z). The primary motion of the worktable is normally accomplished by a rack and pinion drive using a variable

speed motor. As with the shaper, the tool posts are mounted on clapper boxes to prevent interference between the tools and work-piece on the return stroke and the feed motion is intermittent. The size of a standard planer is specified by the size of the largest solid that can reciprocate under the tool. In addition to this, some other parameters such as table size (length and width), type of drive, number of speeds and feeds available, power input, weight of the machine, floor space required etc. may be required to specify a planer completely.

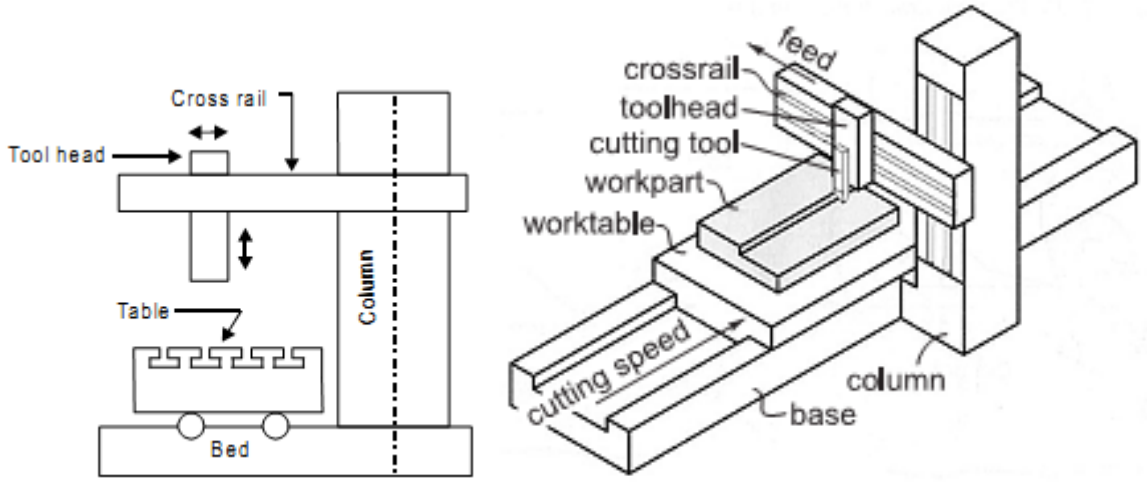


Figure 4.2. Components of an open-side planer.

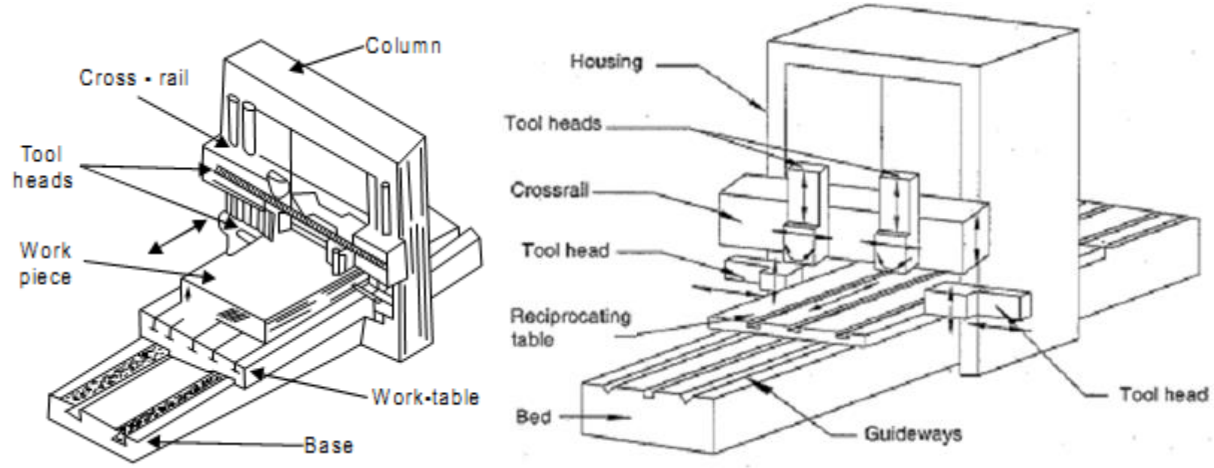


Figure 4.3. Principle parts of double housing planer.

4.3. Principal Parts of a Planer

The principal parts of a double housing planer, as shown in Figure 4.2. and 4.3. are as follows:

1. **Bed:** The bed of a planer is a box like casting having cross ribs. It provides the foundation for the machine and supports the housing and all other moving parts. The up-per part of the bed is provided with precision Vee type guide ways on which the table slides.

2. **Table:** The planer table is a heavy rectangular precision machined casting. It reciprocates along the ways of the bed and supports the work. The top face of the table is provided with T-slots and holes uniformly spaced for fixing the work and work holding devices over the table with the help of T-bolts, clamps etc. The table may be driven by rack and gear, by rack and double helical gear or by hydraulic system.

3. **Housing:** The housings are rigid column-like castings placed on each side of the bed. The front face of the housings is accurately machined to provide precision ways. The housings enclose the cross-rail elevating screws, vertical and cross-feed screws for the tool heads, counter balancing weights for the cross-rail etc.

4. **Cross-rail:** The cross-rail is mounted on the precision machined ways of the two housings. It may be raised or lowered on the housings to accommodate work of different heights on the table and to allow for the adjustment of the tools.

5. **Tool heads:** The tool heads are mounted on the cross-rail or housings by means of a saddle which slides along the rail or housing ways. The saddle may be made to move transversely on the cross-rail to give cross feed. Two tool heads are provided on the cross-rail so that the two tools may remove the material from the work simultaneously. In addition to these two-tool heads, there are other two-tool heads which are mounted on each housing.

4.4. Operating Conditions in planers

4.4.1. Cutting speed and Feed

- Cutting speed of planer is similar to shaper
- The feed in a planing machine is the distance the tool travels at the beginning of each cutting stroke and is expressed in mm/double stroke

4.4.2. Size and Specifications of a Planer

The size of planer and shaper are specified by the maximum length of stroke. The normal maximum stroke length of the of planer stroke is 800mm.

The planer size is generally given by the following:

1. Width of the table in mm,
2. Maximum distance of the table to the cross-rail in meters, and
3. Maximum stroke of the table in mm.

For example, a standard or double housing planer of size 750 mm × 350 mm × 2.5 m means that a planer can machine a work of width 750 mm, height 350 mm and length 2.5 m. The double housing planers are also available in size up to 3000 mm × 3000 mm × 18.25 m.

In addition to the above planer size, the following particulars are also given to specify the planer:

1. Length of bed,
2. Length of the table,
3. Type of drive,
4. Power of the motor, and
5. Number of speed and feed etc.

4.5. Difference between a Planer and a Shaper

The main difference between shaper and planner operation is given in Table 4.1.

Table 4.1 Difference between Shaper and Planer

S.No.	Shaper	Planer
1	The work is held stationary and the cutting tool on the ram is moved back and forth across the work	In a planer, the tool is stationary (fixed) and the workpiece travels (moves) back and forth under the tool.
2	It is used for shaping much smaller jobs. Tools used are of smaller size.	It is adopted for large works. A planer is meant for much larger jobs than can be undertaken on a shaper, as large as 6m wide and twice as long can be machined on a planer. Tools used are of larger size.
3	A shaper is a light machine	It is a heavy duty machine tool.
4	Shaper can employ light cuts and finer feed. It cannot take deep cuts.	Planer can employ heavier cuts and coarse /heavier feeds are applied. It can take deep cuts.

S.No.	Shaper	Planer
5	A shaper uses one cutting tool only at a time	More than one cutting tool can be used at a time. Several tools can cut simultaneously on a planer
6	Shaper is driven using quick- return link mechanism, Normally by crank and slotted lever quick return motion mechanism.	The drive on the planer table is either by gears or by hydraulic means
7	It is less rigid and less robust	Because of better rigidity of planer, as compared to that of a shaper, planer can give more accuracy on machined surfaces.
8	It requires less floor area.	It requires more floor area.
9	Work may be clamped easily and quickly.	Work setting requires much of skill and takes longer time.

Self-check - 4

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.** (1 point for each)

1. The size of planer and shaper are specified by the maximum length of stroke
2. The feed in a planing machine is the distance the tool travels at the beginning of each cutting stroke and is expressed in mm/single stroke

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives. (1 point for each)

1. The planer size is generally given by _____.
   (a) Width of the table in mm,
   (b) Maximum distance of the table to the cross-rail in meters
   (c) Maximum stroke of the table in mm
   (d) All

2. Planner operation is not employed for
   (a) For much larger jobs
   (b) For light cuts and finer feed
   (c) For more accuracy on machined surfaces
   (d) All

Part III: Marching - Instructions: For the following questions match from **"B" to "A" column** (1 point for each)

No.	"A" Column	"B" Column
_____ 1.	*Open side planer*	A. Similar to shaper
_____ 2.	*Double-column planer*	B. provide a more rigid structure for the operation but limit the width of the work that can be handled
_____ 3.	Cutting speed of planer	C. has a single column supporting the cross-rail on which a tool head is mounted

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers. (2 points)

1. The fundamental difference of the planer has with the shaper is _____.
2. List dawn the main types of planning machines

ANSWER SHEET

True or False

1. True
2. False

Multiple Choice

1. (d)
2. (d)

Marching

1. C
2. B
3. A

Short Answer Questions

1. The fundamental difference of the planer has with the shaper is, Planer operates opposite to that of the shapers, i.e., the work piece reciprocates past one or mare stationary single point cutting tools.
2. Types of planing machines include Universal planer, pit type planer and edge planer. Planer can be classified as either open side planers or double-column planers.

Unit Five: Perform precision Slotting operations

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Precision slotting operations feathered and tapered keyways, slotting internal cavities, dovetails, slotting circular surfaces and internal splines

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Carry out Precision slotting operations feathered and tapered keyways, slotting internal cavities, dovetails, slotting circular surfaces and internal splines

5. Carrying out Precision slotting operations

5.1. Slotting Machine

The spotter or slotting machine is also a reciprocating type of machine tool similar to a shaper or a planer. It may be considered as a vertical shaper. The chief difference between a shaper and a spotter is the direction of the cutting action. The machine operates in manner similar to the shaper, however, the tool moves vertically rather than in a horizontal direction. The job is held stationary. The spotter has a vertical ram and a hand or power operated rotary table.

Slotters are commonly used for internal machining of blind holes, or vertical machining of complicated shapes that are difficult to machine on horizontal shapers. They are useful for machining keyways, and cutting of internal and external teeth on large gears.

As illustrated in Figure 5.1., the job is generally supported on a round table (3) that has a rotary feed in addition to the usual table movement in cross-directions. The ram (1) travels vertically along the ways of the column (2). The ram stroke of a slotter ranges from 300 to 1800 mm. The slotters are generally very robust machines and there is a possibility of tilting the ram up to ±15° from vertical to permit machining of dies with relief.

The rams are either crank-driven or hydraulically driven. Ram speeds are usually from 2 to 40 m/min. Longitudinal and transverse feeds range from 0.05 to 2.5 mm/stroke. Cutting action takes place on downward stroke.

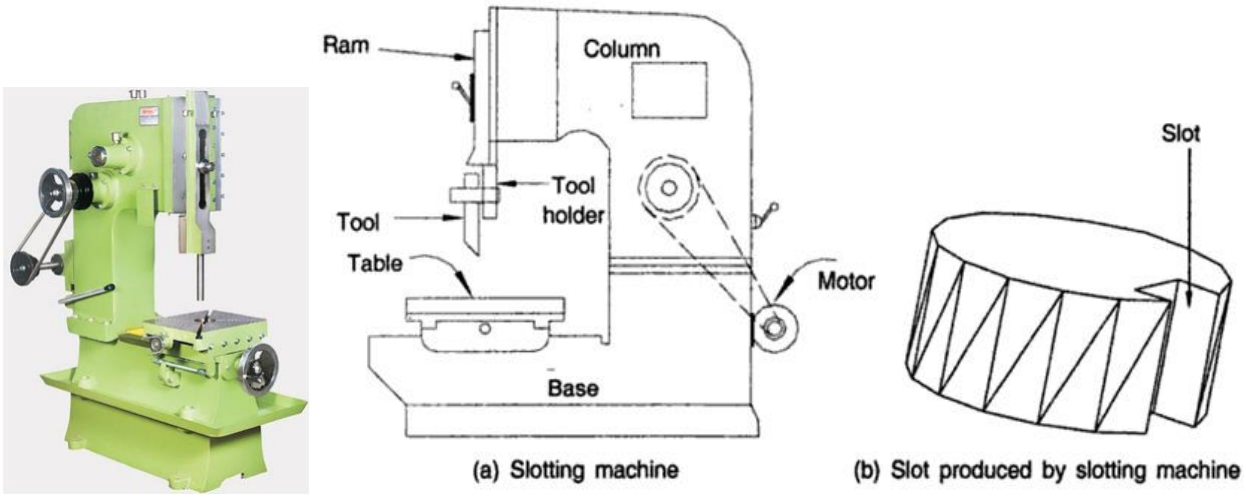


Figure 5.1. Slotting machine and a slot produced by slotting machine

5.1.1. Principle Parts of a Slotting machine

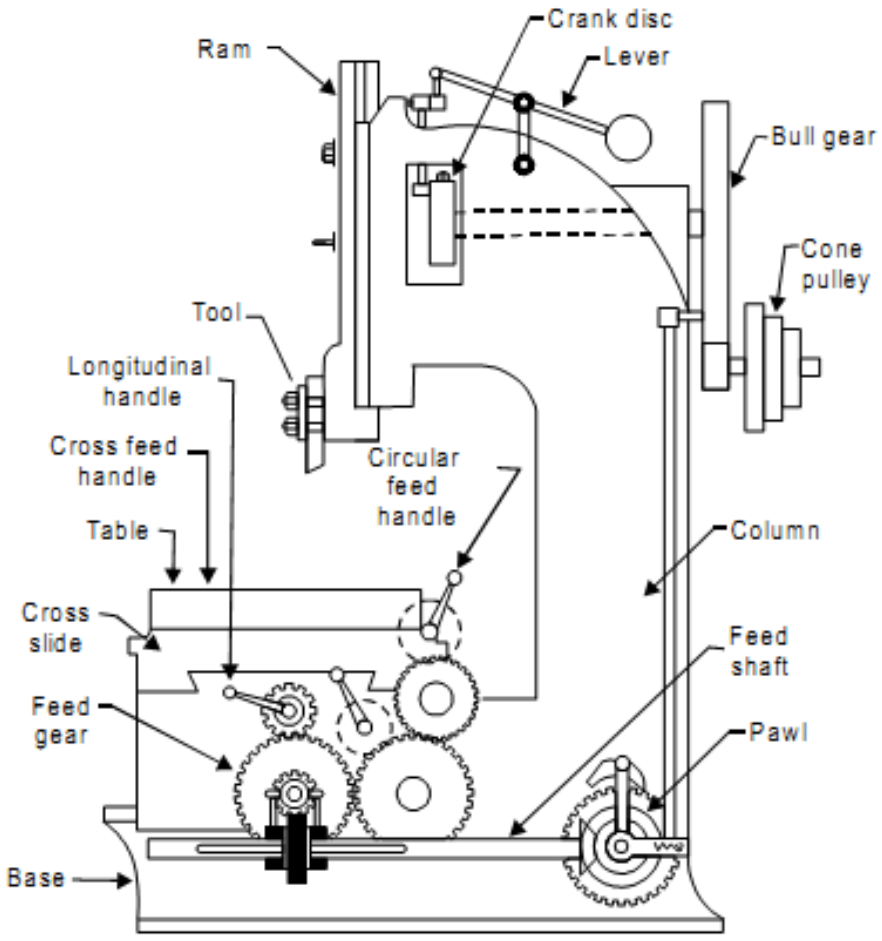


Figure 5.2. Slotter and its various parts

Figure 5.2. Shows a spotter and its various parts. The main parts of a slotter are discussed as under:

Bed or Base

- It is made up of cast iron. It supports column, tables, ram, driving mechanism etc. The top of the bed carries horizontal ways along which the worktable can traverse.

Table

- It holds the work piece and is adjustable in longitudinal and cross-wise directions. The table can be rotated about its centre.

Hand Wheels

- They are provided for rotating the table and for longitudinal and cross traverse.

Column is the vertical Member

- They are made up of cast iron and it houses the driving mechanism. The vertical front face of the column is accurately finished for providing ways along which the ram moves up and down.

Ram

- It is provided to reciprocate vertically up and down. At its bottom, it carries the cutting tool.
- It is similar to the ram of a shaper; but it is more massive and moves vertically, at right angle to the worktable, instead of having the horizontal motion of a shaper:

Cross-Slide

- It can be moved parallel to the face of the column. The circular work-table is mounted on the top of the cross-slide.

5.1.2. Operations Performed on a Slotting Machine

Precision Slotting Operations are carried out including feathered and tapered keyways, slotting internal cavities, dovetails, slotting circular surfaces and internal spines.

A slotter is a very economical machine tool when used for certain classes of work given as under.

- It is used for machining vertical surfaces
- It is used angular or inclined surfaces
- It is used to cut slots, splines keyways for both internal and external jobs such as machining internal and external gears,
- It is used for works as machining concave, circular, semi-circular and convex surfaces

- It is used for shaping internal and external forms or profiles
- It is used for machining of shapes which are difficult to produce on shaper
- It is used for internal machining of blind holes
- It is used for machining dies and punches, and
- Since a slotter works slowly. It has less use in mass production work. It can be substituted by the broaching machine.

Milling machine slotting attachments

Slotting attachments is one milling machine attachments, which is designed to be attached to the spindle and column of the machine **to hold special attachments *Slotting attachments.***

The slotting attachment converts the rotary motion of the spindle into reciprocating motion for cutting key ways, splines, templates, and irregularly shaped surfaces. The length of the stroke is controlled by an adjustable crank.

- A metal slitting saw milling cutters are used for slotting operations, which is held by a short arbor having two flanges used to secure the cutter between them by tightening a clamping nut.
- Side milling cutters are generally used for slotting milling. Side milling cutters are essentially plain milling cutters, that have teeth on the periphery with the addition of teeth on one or both sides, can be used for cutting slots
- These cutters are made with interlocking faces so that two cutters may be placed side by side for slot milling. Interlocking tooth side milling cutters and staggered tooth side milling cutters are used for cutting relatively wide slots with accuracy. Interlocking tooth side milling cutters can be repeatedly sharpening without changing the width of the slot that will be machined and most efficient used for milling slots where the depth exceeds the width. After each sharpening, a washer is placed between the two cutters to compensate for the ground-off metal.

Table 5.1. Recommended feed per tooth (for high speed steel cutters)

Material	**Face mills**		**Helical Mills**		**Slotting and side Mills**		**End mills**		**Form relived Cutters**	
	In	mm	in	mm	in	mm	in	mm	in	mm
Aluminum	0.022	0.55	0.018	0.45	0.013	0.33	0.011	0.28	0.007	0.18
Brass & Bronze	0.014	0.35	0.011	0.28	0.008	0.20	0.007	0.18	0.004	0.10
Machine steel	0.012	0.30	0.010	0.25	0.007	0.18	0.006	0.15	0.004	0.10
Tool steel (medium)	0.010	0.25	0.008	0.20	0.006	0.15	0.005	0.13	0.003	0.08
Stainless steel	0.006	0.15	0.005	0.13	0.004	0.10	0.003	0.08	0.002	0.05
Cast iron	0.013	0.33	0.010	0.25	0.007	0.18	0.007	0.18	0.004	0.10

Self-check - 5

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.**

1. A slotter is a very economical machine tool when used for certain classes of work
2. Since a slotter works slowly, it has less use in mass production work.

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives.

1. Cutting action of slotter machine takes place
   (a) On downward stroke (c) on upward stroke
   (b) on downward and upward (d) All

2. Which one of the following cutters are used for cutting relatively wide slots with accuracy?
   (a) Interlocking tooth side milling cutters (c) A and B
   (b) Staggered tooth side milling cutters (d) All

Part III: Marching - Instructions: For the following questions match from **"B" to "A" column**

No.	"A" Column	"B" Column
_____ 1.	Ram	A. holds the work piece and is adjustable in longitudinal and cross-wise directions, and can be rotated about its centre
_____ 2.	Table	B. carries the cutting tool at its bottom, provided to reciprocate vertically up and down at right angle to the worktable

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers.

1. Why is the cutting speed in planing, shaping, and slotting limited by 50–60 m/min?
2. Differentiate between shaper, planer and slotter.
3. Make neat sketch of a slotter. Explain its working with applications.

ANSWER SHEET

True or False

1. True
2. True

Multiple Choice

1. (a)
2. (c)

Marching

1. B
2. A

Short Answer Questions

1.
2.

Unit Six: Check component for conformance to specification
This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics: • Techniques, tools and equipment for checking conformance component. This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Check component for conformance using appropriate techniques, tools and equipment

6. Checking component for conformance

6.1. Introduction

A product is manufactured to perform desired functions. It must have a specified dimension such as length, width, height, diameter and surface smoothness to perform or accomplish its intended function. It means that each product requires a defined size, shape and other characteristics as per the design specifications. For manufacturing the product to the specified size, the dimensions should be measured and checked during and after the manufacturing process. It involves measuring the size, smoothness and other features, in addition to their checking. These activities are called measurement and inspection respectively.

Inspection or checking of components or products with required specifications is very minutely related with quality control. It is generally an accepted fact that no two things can ever be exactly same. It also holds true with manufactured parts. Therefore, certain variations or deviations in dimensions and other product specifications are accepted. However, only few produced articles or parts may be rejected if the deviations go beyond the specified quality standards. Therefore, it becomes essential to detect errors so that the manufacturing of faulty product does not go uncorrected.

The quality of manufactured product is depend always upon the process capability of controlling manufacturing functions which may lead to a certain amount of variation as a result of chance and some cause. Also some chance or cause is inherent in any particular scheme of production and inspection. The reasons for variation outside this stable system should be discovered and corrected to minimize wastage and finally to improve quality. The philosophy of inspection is only preventive and not remedial. In other words the inspection of products is measuring or checking its quality in terms geometrical tolerances of other specified feature of needed design.

Generally, there are three basic areas of inspection namely receiving inspection, in-process inspection and final inspection.

1. In the receiving inspection, inspections are performed on all incoming materials and purchased parts.
2. In the in-process inspection the products are inspected as they are in processed in stages from starting station to finished station.
3. In the final inspection, all finished products or parts are inspected finally prior to delivering them to the customer.

6.2. Components of Inspection and Test Plans

The purpose of an Inspection and Test Plan is to put together a single document that records all inspection and testing requirements relevant to a specific process, likely to be a manufacturing activity, element of work, or providing a product section.

An Inspection and Test Plan identifies the items of materials and work to be inspected or tested, by whom and at what stage or frequency, as well as Hold and Witness Points, references to relevant standards, acceptance criteria and the records to be maintained. Inspection and Test Plans, when properly implemented, help ensure that, and verify whether, work has been undertaken to the required standard and requirements, and that records are kept.

There are no set rules as to who should document Inspection and Test Plans. It is appropriate, however, that they receive input from those with a good technical and practical knowledge of, and experience in, the activities involved. The use, understanding and acceptance of ITPs by inspectors and other personnel will generally be greatly enhanced if they are involved in their preparation.

The service provider is responsible for ensuring that all the required Inspection and Test Plans are prepared, including those covering work or processes to be carried out by its service providers.

6.2.1. Description of operation /stage of work requiring inspection /test

Because 100% inspection and testing in most cases is neither practical nor desirable, it is necessary to adopt a testing frequency and sampling process which provides a representative indication of the work to suit the risks involved. Inspections and tests are often best done after a number of separate activities, but prior to a major one that will cover up previous work. Service providers would carry out preliminary tests to assist in obtaining an early indication of conformity. Determining the type and extent of inspections and tests is probably the most challenging aspect of documenting an Inspection and Test Plan. The approvals required are sometimes easier to determine as they are usually specified and identify particular work/stages requiring inspections and tests. The type, timing and frequency of inspections and tests vary to suit the risks and work involved. The type, timing and frequency (the what, when and how often) of inspections and tests are best determined in conjunction with the consideration of the characteristics to be verified.

The “what to test”, “how to test” and “when to test” is governed by:

- What the work is and how complex it is
- Accessibility for inspections and sampling
- Consequences of failure, including as follows:
- Cost of remedial work
- Effect on construction program
- Accessibility for rectification
- Disruption to use of building or structure
- Consequential damage to other elements
- Threat to safety of workers and public
- Availability of resources

6.2.2. Characteristics of inspection/test/approval

The characteristics of a work item can be defined as “a distinguishable property of an item, material or process”. Examples of characteristics are colour, texture, size, strength, flatness, alignment, capacity and the like. The characteristics to be verified will frequently determine the stage at which the inspection or test must take place if the potential for subsequent nonconformities is to be avoided. This further work might also cover up or deny access for the purposes of verifying certain characteristics. Some characteristics can only be considered after one particular operation and before another, such as the inspection of steel reinforcement after installation but prior to the pouring of concrete.

6.2.3. Stage/frequency

The inspection/test stage/frequency will often be determined by the requirements of the contract documents or by the type of inspection and/or test and the characteristics under consideration, as outlined above. In the latter case however, there is the potential for a considerable range in what constitutes the most appropriate frequency and sampling process. It is suggested that a representative sampling of the work to suit the risks involved be used as a guide initially. Thereafter, frequencies would be increased and processes reviewed for „problem“ work activities and decreased where consistent conformity was evidenced.

6.2.4. Acceptance criteria

Acceptance criteria would normally be defined in the contract documents (either directly or by reference to other standards). Where this is not the case it would be necessary to identify them and possibly to agree to them with the customer. It is preferable to establish acceptance criteria with the customer (where they are not specified or clear) to agree the yardsticks (such as test panels/sections or previous work) against which a product/service is to be declared conforming or nonconforming.

6.2.5. Specification/standard

The main motive of manufacturing is to process engineering materials and produce desired and useful components or products to the specified shape, size and finish. The specifications for the shapes, sizes and finishes on the products are furnished by the manufacturing operations through specified process plan using part drawings or manufacturing drawings. These specifications basically termed as called quality characteristics. The standards against which conformity is measured can take various forms. The most common source is usually the contract technical specification. Other standards would often be referenced in this document, and may include any of the following: -

- Contract documents/specification generally
- Contract drawings
- Approved workshop drawings and/or calculations
- Approved technical details/procedures
- Approved samples and/or prototypes
- Regulatory requirements
- International Standards
- Standard specifications
- Manufacturers' recommendations

6.2.6. Inspection/test procedures

Inspection: **-** The ***qualitative observation*** of an item's performance or condition.

For many inspections/tests, the methods employed will be specified or self-evident and determined by the characteristics being examined. In other cases, however, the precise manner in which the inspection/test is carried out would need to be identified and described. A clearly described test procedure will usually be necessary to help achieve consistent and reliable results. In some cases, it may be possible to satisfy the requirements simply by referencing the requirements of International Standards and the like. A typical test procedure using statistical techniques might, for example, cover:

- reference to work areas/lots or batches
- frequency of sampling
- method of taking samples
- method of conducting a test (including conditions)
- qualifications of test personnel and equipment calibration/condition/specification
- method of documenting results

6.2.7. Checklists

The logical stage to carry out an inspection or test is often after a number of separate activities, but prior to a major one that will cover up previous work. It is often useful to complete checklists at such stages and with each inspection and test - where they will, in effect, summarise the procedures that have, and should have, taken place up to the particular point in the work process.

Checklists are useful reminders to the person doing the work of all the matters that are to be addressed. They are used to confirm all the matters have been attended to. They are also reminders to the person inspecting the work of all the matters that should be checked. A checklist also gives an opportunity to record any special or unusual conditions under the contract, and draw these to the attention of the people doing the work. For example, special precautions for protecting existing work, notifications to the public, and other matters that might not normally be required for the particular trade or activity, may be included.

The fact that checklists exist, and that their use and content have been verified, would give a customer confidence that the person doing the work is aware of all the important steps, attributes and matters to be addressed, and the standards that should be complied with, and that conformity is being verified.

Sample Checklist

INSPECTION AND TEST PLAN CHECKLIST for: (To be completed by the person(s) directly responsible for the work)				
Contract Number: Contract/Project Name: Contractor: Subcontractor		Work area:		Checklist Number:
Work	Items/activities to be verified	Reference	Initialled/OK	Comments
I have carried out all necessary inspections and verify that the above items/activities conform to the contract specification/documents				Name: Signature: Date:
I have carried out all necessary inspections and verify that the above work for this work area has been completed and conforms to the contract specification/documents				Name: Signature: Date:

Inspection and Test Plan Sample forms with Example

Customer: Contract Number: Contract/Project Name:				INSPECTION AND TEST PLAN for: (Insert work activity, Example Manufacturing) Work area: (Insert work area)						Insert Contractor Identification and/or Logo
Ref	**Operation /stage of work**		**Stage/ frequency**	**Records**	**Requirement /standard/ specification**	**Acceptance criteria**	**Inspection /test procedure**	**Inspection *what/who**		
	Description	**Characteristics**						**Employee**	**Service provider**	**Customer**
1	Incoming materials inspection	Conform to order	Each delivery	Delivery dockets/ Checklist	Orders as placed	Specification & code, GPC approved & colour sched.	Check against orders	H	W	
2	Storage and protection	As specified	Each week	Checklist	Specification, as attached	Safe, secure /adequate protection	Visual	X	S	S
3	Preliminary activities	Task completion	Each work area	Checklist	Specification, as attached, WHS practice & Regulation	All tasks completed	Visual	H	W	S
4	Pre-start	Ready to commence works	Each work area	Checklist	Specification, as attached	To authority requirements	Checked	H	W	S
5	Carry out work	To trade codes and authority requirements	Each work area	Checklist	Specification, as attached	Checklist and test panel	Checked	H(A)	W	S
6	Surface preparation	Ready to paint, clean and smooth	Each work area	Checklist	Specification, as attached	Smooth and clean	Visual	H	H	W
7	Painting	Full & uniform cover, smooth, colour	Each work area	Checklist	Specification, as attached	Checklist and test panel	Visual	X	S, H(C)	S
8	Pre-handover activities	All matters finalised, clean and tidy	Each work area	Wiring diagram /Checklist	Specification, as attached	All items Completed to spec/clean and tidy	Final inspection	H	H	H
*W = Witness Point; H = Hold Point; H(A) = Inspection/Test by Authority; U(C) = Inspection/Test by Consultant; S = Surveillance or monitoring; X = Self inspection by performer of work.										

Self-check - 6

Directions: Attempt to answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers. Note: Be precise and scientific in writing.

Part I - Instructions: For the following questions say **True** or **False.**

1. A product is manufactured to perform or accomplish its intended function, it must have a specified dimension such as length, width, height, diameter and surface smoothness.
2. It is generally an accepted fact that no two manufactured parts can ever be exactly same.

Part II: Multiple Choice - Instructions: For each of the following question **choose the best correct answer** and **circle the letter** of your choice from the given alternatives.

1. Acceptance criteria would normally be defined _____.
   (a) in the contract documents
   (b) either directly or by reference to other standards
   (c) to identify them and possibly to agree to them with the customer
   (d) All

2. A clearly described test procedure will usually be necessary to _____.
   (a) help achieve consistent
   (b) help achieve and reliable results
   (c) to satisfy the requirements
   (d) All

Part III: Marching - Instructions: For the following questions match from **"B" to "A" column**

No.	"A" Column	"B" Column
_____ 1.	Receiving inspection	A. the products are inspected as they are in processed in stages from starting station to finished station
_____ 2.	In-process inspection	B. inspections are performed on all incoming materials and purchased parts
_____ 3.	Final inspection	C. all finished products or parts are inspected finally prior to delivering them to the customer.

PART IV: Short Answer Questions - Instructions: Write the answer for the following questions properly. If it is necessary aid some explanations or examples on the answers.

1. List down some of the standards forms against which conformity is measured can take
2. The “what to test”, “how to test” and “when to test” is governed by

ANSWER SHEET

True or False

1. True
2. True

Multiple Choice

1. (d)
2. (d)

Marching

1. B
2. A
3. C

Short Answer Questions

1.
2.

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WEB Address

- http://www.qualitygurus.com/courses/mod/forum/discuss.php?d=1557

Developers Profile

No.	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1						
2						
3						
4						
5						
6						
7						