Department of Mechanical Engineering
MALLA REDDY ENGINEERING COLLEGE (Autonomous)

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COURSE MATERIAL
OF
"MACHINE TOOLS"

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2017-18 Onwards (MR-17)	MALLA REDDY ENGINEERING COLLEGE (Autonomous)	B.Tech. VI Semester		
Code:70325	**MACHINE TOOLS**	**L**	**T**	**P**
Credits:3		3	-	-

Prerequisites: Production Technology

Course Objectives:
The objective of this subject is to provide knowledge of all machine tools and to measure cutting forces while machining.

MODULE I: Metal Cutting Theory 10 Periods

Metal Cutting Theory: Elements of cutting process- Geometry of single point cutting tool and angles, Tool signature, chip formation and types of chips- built up edge and its effects, chip breakers. Mechanics of orthogonal cutting- Merchant's Force diagram, cutting forces- cutting speeds, feed, depth of cut, tool life, coolants, machineability - Tools materials. Cutting tool temperature measuring methods.

MODULE II: Lathe Machine 10 Periods

Lathe Machine: Principle of working, Specification of Lathe- types of Lathe- Work holders, tool holders-Box tools, Taper turning, thread cutting for Lathe attachments. Turret and Capstan lathe- collet chucks- other work holders- tool holding devices- box and tool layout. Principal features of automatic lathe- Classification- Single spindle and multi-spindle automatic lathe.

MODULE III: Shaping, Slotting, Planning, Drilling and Boring Machines 10 Periods

A: Shaping, Slotting and Planning Machines: Principles of working- Principal parts- specification, classification, operations performed. Machining time calculations.

B: Drilling and Boring Machines: Principles of working, specifications, types, operations performed- tool holding devices- twist drills- Boring machines-Fine Boring machines- Jig Boring machine. Deep hole drilling machine.

MODULE IV: Milling Machine & Grinding Machine 09 Periods

Milling Machine : Principles of working-specifications-classifications of milling machines- principal features of horizontal, vertical and universal milling machines- machining operation types, geometry of milling cutters- milling cutters- methods of indexing- Accessories to milling machines and milling cutters-methods of indexing.

Grinding Machine: Fundamentals- Theory of grinding- classification of grinding machine- cylindrical and surface grinding machine- Tool and cutter grinding machine- special types of grinding machines- Different types of abrasives- bonds specification of a grinding wheel and selection of a grinding wheel.

MODULE V: Lapping, Honing and Broaching Machines & Principles of Design of Jigs and Fixtures **09 Periods**

Lapping, Honing and Broaching Machines : Lapping, honing and broaching machines- principle of working, specification of broaching machines, methods of broaching, broaching tools, Classification of Broaching machines, operations.

Comparison to grinding- lapping and honing- Kinematics scheme of Lapping, Honing and Broaching machines. Constructional features of speed and feed units, machining time calculations. Principles of design of Jigs and Fixtures: Classification of Jigs and Fixtures- Principles of location and clamping- Types of clamping & work holding devices. typical examples of Jigs and Fixtures.

TEXT BOOKS

1. P.C. Sharma, "**Production Technology (Machine Tools**)", S.Chand Publishers, 7th edition, 2006.
2. Pakirappa, "**Metal Cutting and Machine Tool Engineering"**, Durga publication house, 1st edition, 2012.

REFERENCES

1. C.Elanchezhian and M.Vijayan, "**Machine Tools**", Anuradha Agencies Publishers,2nd edition, 2008
2. B.S.Raghuvamshi, "**Workshop Technology-Vol** II", Anuradha Agencies Publishers, Dhanpat rai & company, 10th revised edition, 2014.
3. Steve F.Krar, Arthur R.Gill, PeterSmid Krar, Stephen F, "**Technology of Machine tools"**, Mc Graw-Hill, 7th edition , 2011.
4. B.L.Juneja,"**Fundamentals of Metal cutting and machine tools**", New age Int. publishers, 2nd edition , 2017.
5. R.K.Jain and S.C.Gupta, "**Production Technology**", Khanna Publications, 16th edition, 2014.

E - RESOURCES

1. http://nptel.ac.in/courses/112105126/5
2. https://www.journals.elsevier.com/international-journal-of-machine-tools
3. www.sciencedirect.com/science/journal/08906955/64

Course Outcomes

At the end of the course, students will be able to

1. Understand the basic concepts of metal cutting theory.
2. Know the working principles of different Lathes and its parts.
3. Know the working principles of special machines like shaping, slotting, planning& drilling machines.
4. Know the working principles of milling and grinding machines.
5. Know the working principles of lapping, honing, broaching and jigs & fixtures.

Module-I

METAL CUTTING THEORY

Instructional Objectives

At the end of this lesson, the students should be able to :

(a) Describe the basic functional principles of machine tools
  (i) Illustrate the concept of Generatrix and Directrix
  (ii) Demonstrate Tool – work motions
  (iii) Give idea about machine tool drives

(b) Show configuration of basic machine tools and state their uses

(c) Give examples of machine tools - specification

(d) Classify machine tools broadly.

Basic functional principles of machine tool operations

Machine Tools produce desired geometrical surfaces on solid bodies (preformed blanks) and for that they are basically comprised of;

- Devices for firmly holding the tool and work
- Drives for providing power and motions to the tool and work
- Kinematic system to transmit motion and power from the sources to the tool-work
- Automation and control systems
- Structural body to support and accommodate those systems with sufficient strength and rigidity.

For material removal by machining, the work and the tool need relative movements and those motions and required power are derived from the power source(s) and transmitted through the kinematic system(s) comprised of a number and type of mechanisms.

(i) Concept of Generatrix and Directrix

- Generation of flat surface

The principle is shown in Fig. 2.1 where on a flat plain a straight line called Generatrix (G) is traversed in a perpendicular direction called Directrix (D) resulting a flat surface.

- Generation of cylindrical surfaces

The principles of production of various cylindrical surfaces (of revolution) are shown in Fig. 2.2, where,

- A long straight cylindrical surface is obtained by a circle (G) being traversed in the direction (D) parallel to the axis as shown in Fig. 2.2(a)
- A cylindrical surface of short length is obtained by traversing a straight line (G) along a circular path (D) as indicated in Fig. 2.2(b)
- Form cylindrical surfaces by rotating a curved line (G) in a circular path (D) as indicated in Fig. 2.2 (c and d).

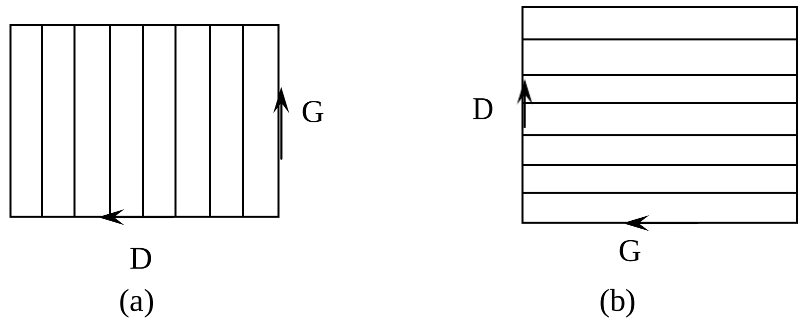


Fig. 2.1 *Generation of flat surfaces by Generatrix and Directrix.*

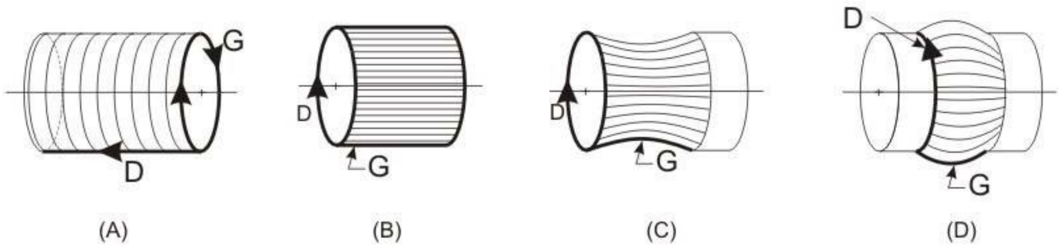


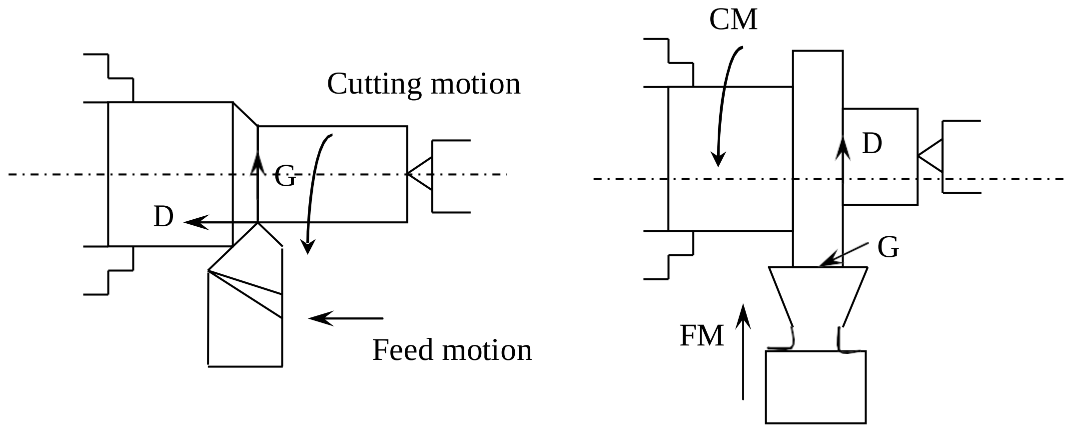
Fig. 2.2 *Generation of cylindrical surfaces (of revolution)*

(ii) Tool – work motions

The lines representing the Generatrix and Directrix are usually produced by the locus of a point moving in two different directions and are actually obtained by the motions of the tool-tip (point) relative to the work surface. Hence, for machining flat or curved surfaces the machine tools need relative tool work motions, which are categorized in following two groups:

- Formative motions namely
  - Cutting motion (CM)
  - Feed motion (FM)
- Auxiliary motions such as
  - Indexing motion
  - Additional feed motion
  - Relieving motion

The Generatrix and Directrix, tool and the work and their motions generally remain interconnected and in different way for different machining work. Such interconnections are typically shown in Fig. 2.3 for straight turning and in Fig.
for shaping.



(a) longitudinal turning (b) transverse turning

Fig. 2.3 *Principle of turning (cylindrical surface)*

The connections in case of straight longitudinal turning shown in Fig. 2.3 (a) are:

Generatrix (G) – Cutting motion (CM) – Work (W)
Directrix (D) – Feed motion (FM) – Tool (T)

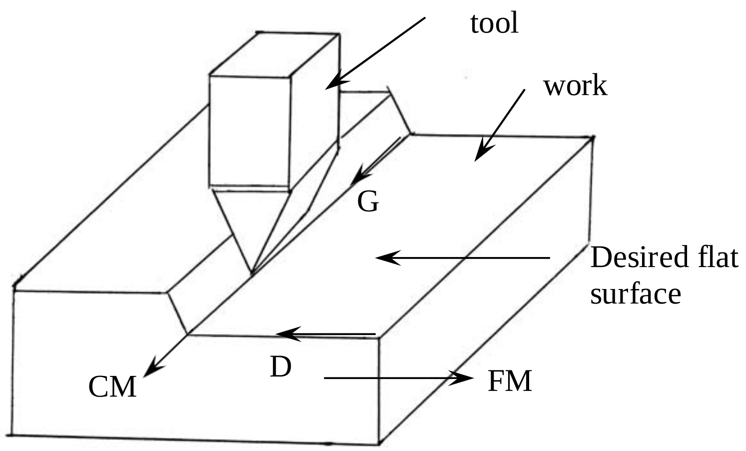


Fig. 2.4 *Principle of producing flat surface in shaping machine*

In case of making flat surface in a shaping machine as shown in Fig. 2.4 the connections are:

G – CM – T
D – FM – W

which indicates that in shaping flat surfaces the Generatrix is provided by the cutting motion imparted to the cutting tool and the Directrix is provided by the feed motion of the work.

Flat surfaces are also produced by planning machines, mainly for large jobs, where the cutting motion is imparted to the work and feed motion to the tool and the connections will be:

G – CM – Work
D – FM – Tool

The Genratrix and Directrix can be obtained in four ways:

- Tracing (Tr) – where the continuous line is attained as a trace of path of a moving point as shown in Fig. 2.3 and Fig. 2.4.
- Forming (F) – where the Generatrix is simply the profile of the cutting edge as indicated in Fig. 2.2 (c and d)
- Tangent Tracing (TTr) – where the Directrix is taken as the tangent to the series of paths traced by the cutting edges as indicated in Fig. 2.5.
- Generation (G): Here the G or D is obtained as an envelope being tangent to the instantaneous positions of a line or surface which is rolling on another surface. Gear teeth generation by hobbing or gear shaping is the example as can be seen in Fig. 2.6.

Fig. 2.5 typically shows the tool-work motions and the corresponding Generatrix (G) and Directrix (D) while producing flat surface by a plain or slab milling cutter in a conventional horizontal arbour type milling machine. The G and D are connected here with the tool work motions as

G – x – T – F
D – FM – W – T.Tr
CM – T

Here G and D are independent of the cutting motion and the G is the line of contact between the milling cutter and the flat work surface. The present cutter being of roller shape, G has been a straight line and the surface produced has also been flat. Form milling cutters will produce similar formed surfaces as shown in Fig. 2.7 where the 'G' is the tool-form.

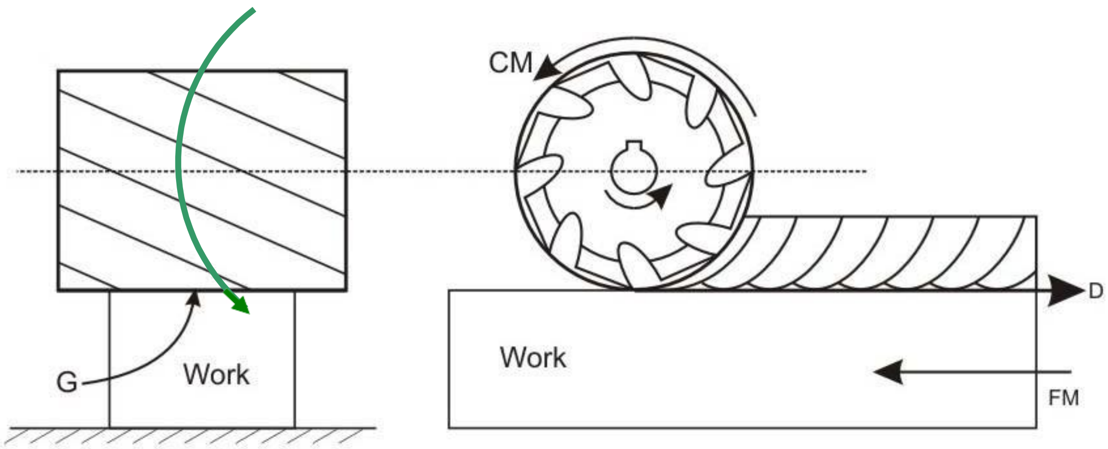


Fig. 2.5 *Directrix formed by tangent tracing in plain milling*

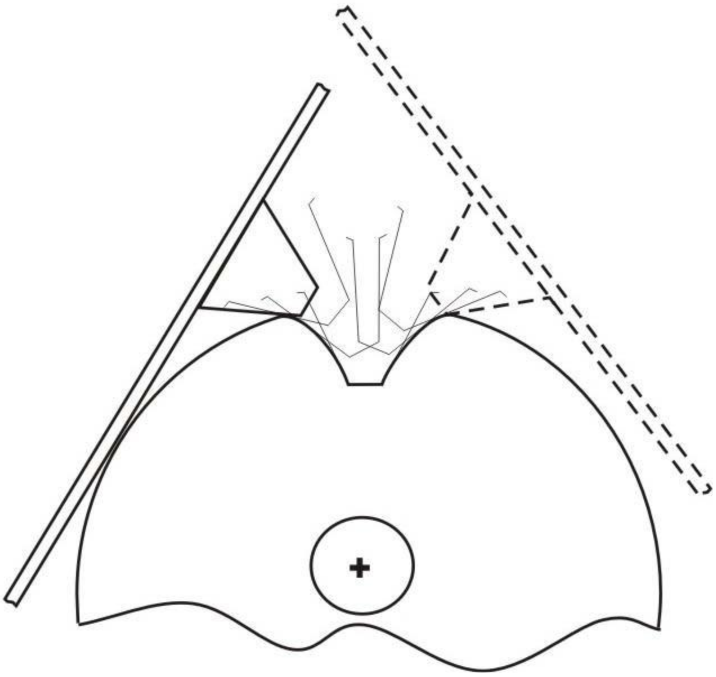


Fig. 2.6 *Generatrix (or Directrix) in gear teeth cutting by generation.*

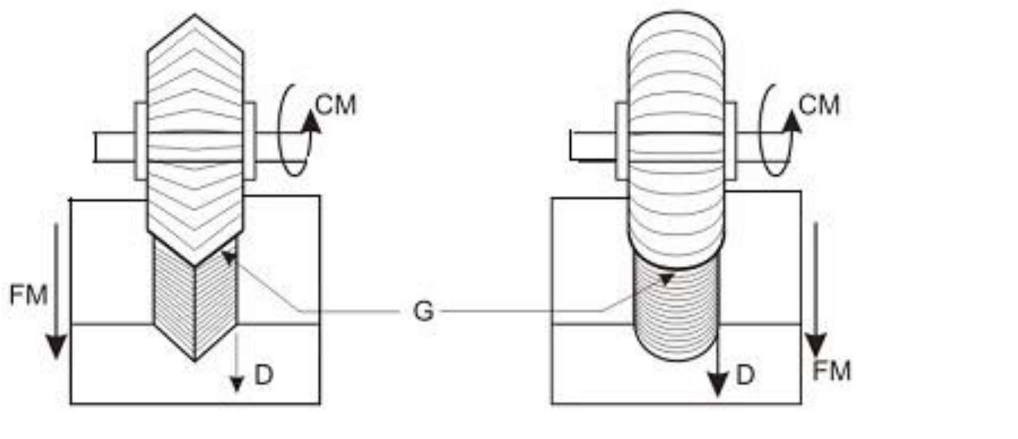


Fig. 2.7 *Tool-work motions and G & D in form milling*

For making holes in drilling machines both the cutting motion and the feed motion are imparted to the cutting tool i.e., the drill bit whereas the workpiece remains stationary. This is shown in Fig. 2.8. The G and D are linked with the tool-work in the way:

G – CM – T – Tr
D – FM – W – Tr

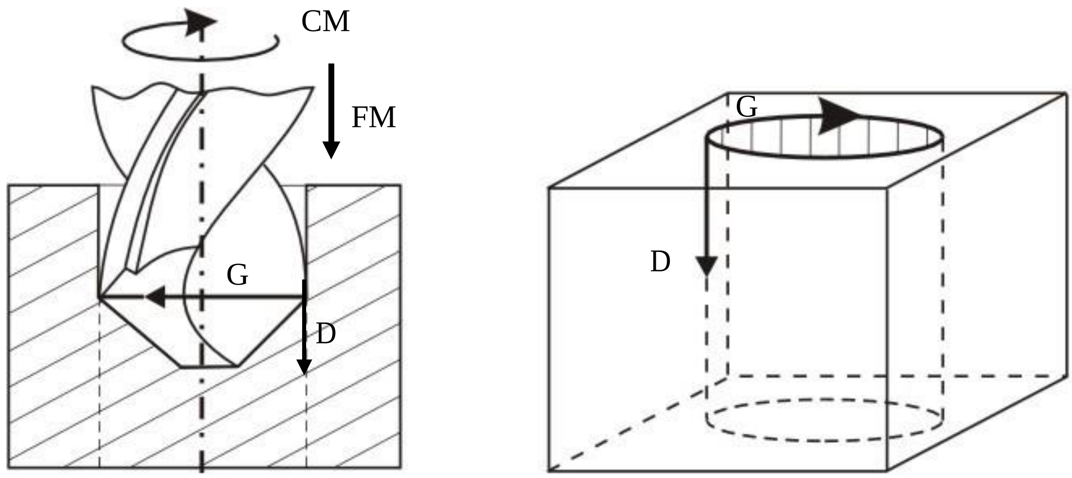


Fig. 2.8 *Tool-work motions and G & D in drilling.*

Boring machines are mostly used for enlargement and finishing of existing cylindrical holes. Boring machines are of two types:

- Vertical boring machine – low or medium duty and high precision, e.g., Jig boring machine
- Horizontal axis boring machine – medium or heavy duty.

In respect of tool-work motions and G and D, vertical boring and drilling are same. In horizontal boring machine the feed motion is imparted to the work to provide the Directrix by Tracing.

(iii) Machine tool drives

For the desired tool-work motions with power, machine tools are driven by electric motors and use of some mechanisms like belt-pulley, gears etc. In some machine tools, the tool-work motions are provided by hydraulic drive also.

Machine tools essentially need wide ranges of cutting speed and feed rate to enable

- Machining different jobs (material and size)
- Using different cutting tools (material, geometry and size)
- Various machining operations like high speed turning to low speed thread cutting in lathes
- Degree of surface finish desired.

Machine tool drives may be

- Stepped drive
- Stepless drive

Stepped drives are very common in conventional machine tools where a discrete number of speeds and feeds are available and preferably in

(Geometric Progression) series. Whereas the modern CNC machine tools are provided with stepless drives enabling optimum selection and flexibly automatic control of the speeds and feeds.

Stepped drive is attained by using gear boxes or cone pulley (old method) along with the power source. Stepless drive is accomplished usually by

- Variable speed AC or DC motors
- Stepper or servomotors
- Hydraulic power pack

Configuration of Basic Machine Tools and their use

- **Centre lathes**
  - configuration

Fig. 2.9 shows the general configuration of center lathe. Its major parts are:

- o Head stock: it holds the blank and through that power and rotation are transmitted to the job at different speeds
- o tailstock: supports longer blanks and often accommodates tools like drills, reamers etc for hole making.
- o carriage: accommodates the tool holder which in turn holds the moving tools
- o bed: ⊗ headstock is fixed and tailstock is clamped on it. Tailstock has a provision to slide and facilitate operations at different locations
  ⊗ carriage travels on the bed o

columns: on which the bed is fixed

- o work-tool holding devices

↓ uses of center lathes

Centre lathes are quite versatile being used for various operations:

↓ turning — external / internal — straight / taper / stepped

↓ facing, centering, drilling, recessing and parting

↓ thread cutting; external and internal

↓ knurling.

Some of those common operations are shown in Fig. 2.10. Several other operations can also be done in center lathes using suitable attachments.

- **Shaping machine**

Fig. 2.11 shows the general configuration of shaping machine. Its major parts are:

- o Ram: it holds and imparts cutting motion to the tool through reciprocation
- o Bed: it holds and imparts feed motions to the job (blank)
- o Housing with base: the basic structure and also accommodate the drive mechanisms

o Power drive with speed and feed change mechanisms.

Shaping machines are generally used for producing flat surfaces, grooving, splitting etc. Because of poor productivity and process capability these machine tools are not widely used now-a-days for production.

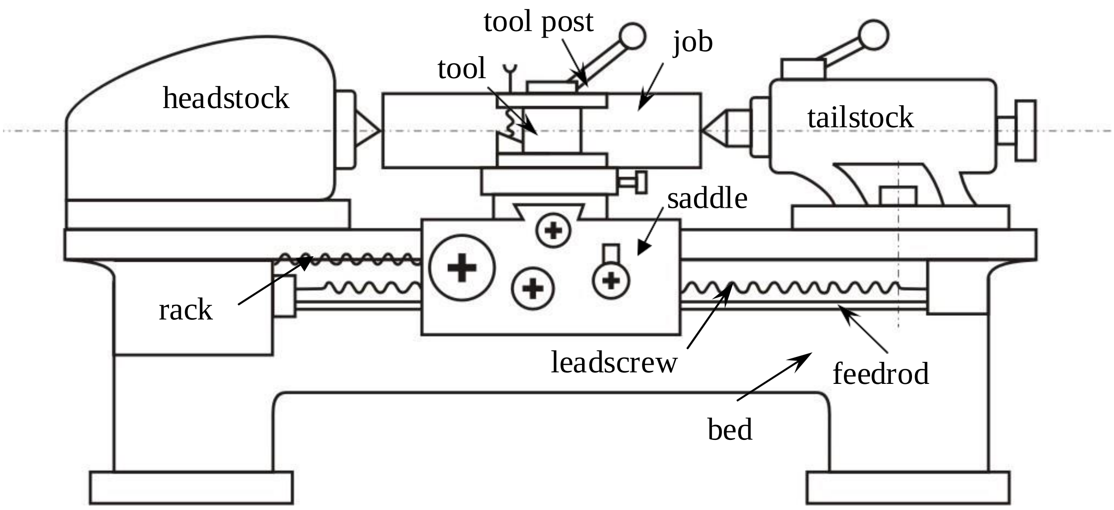


Fig. 2.9 *Schematic view of a center lathe*

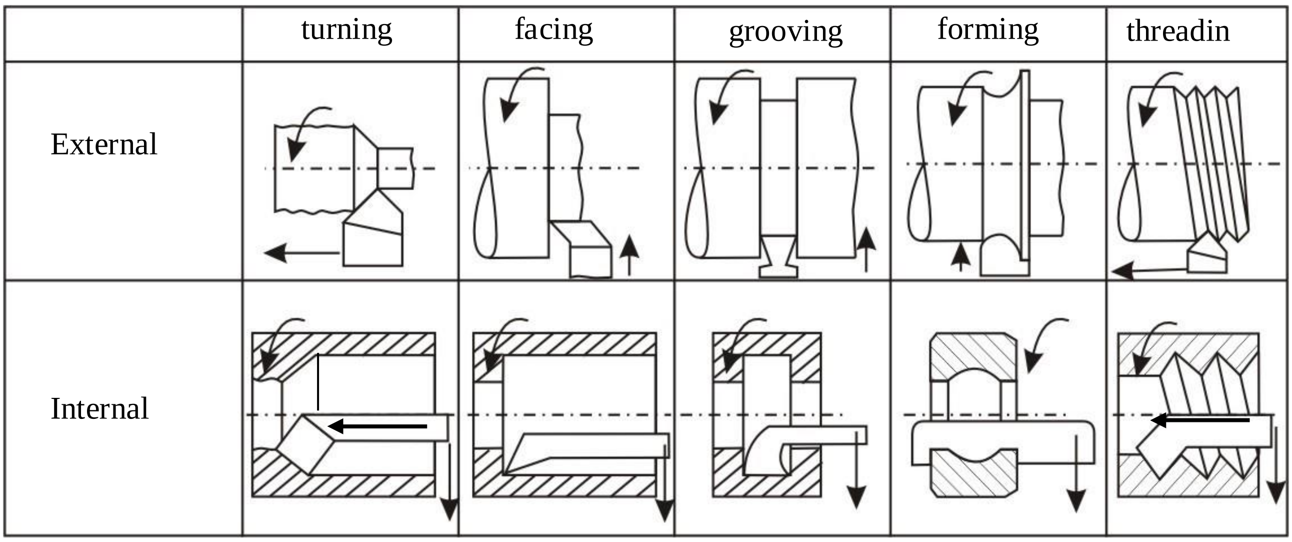


Fig. 2.10 *Some common machining operations done in center lathes.*

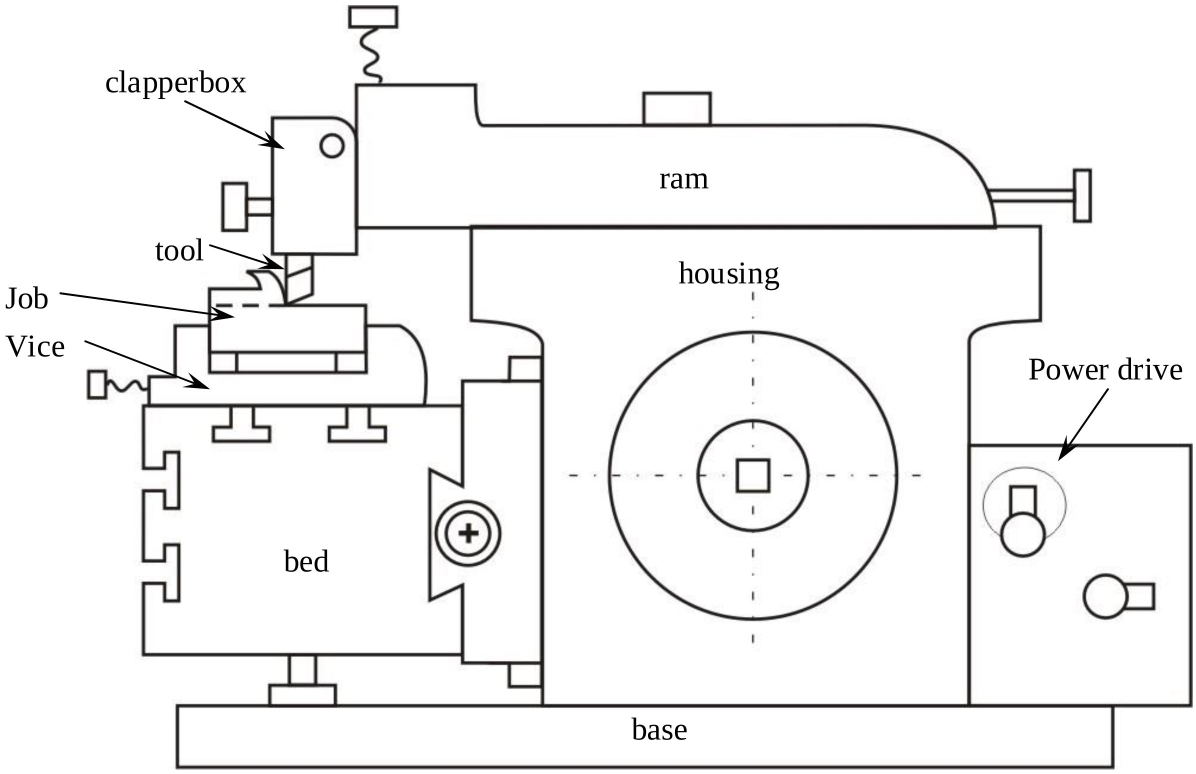


Fig. 2.11 *Schematic view of a shaping machine*

- **Planing machine**

  The general configuration is schematically shown in Fig. 2.12. This machine tool also does the same operations like shaping machine but the major differences are:
  - In planing the job reciprocates for cutting motion and the tool moves slowly for the feed motions unlike in shaping machine.
  - Planing machines are usually very large in size and used for large jobs and heavy duty work.

- **Drilling machine**

  Fig. 2.13 shows general configuration of drilling machine, column drill in particular. The salient parts are
  - Column with base: it is the basic structure to hold the other parts
  - Drilling head: this box type structure accommodates the power drive and the speed and feed gear boxes.
  - Spindle: holds the drill and transmits rotation and axial translation to the tool for providing cutting motion and feed motion – both to the drill.

    Drilling machines are available in varying size and configuration such as pillar drill, column drill, radial drill, micro-drill etc. but in working principle all are more or less the same.

  Drilling machines are used:
  - Mainly for drilling (originating or enlarging cylindrical holes)

- Occasionally for boring, counter boring, counter sinking etc.
- Also for cutting internal threads in parts like nuts using suitable attachment.

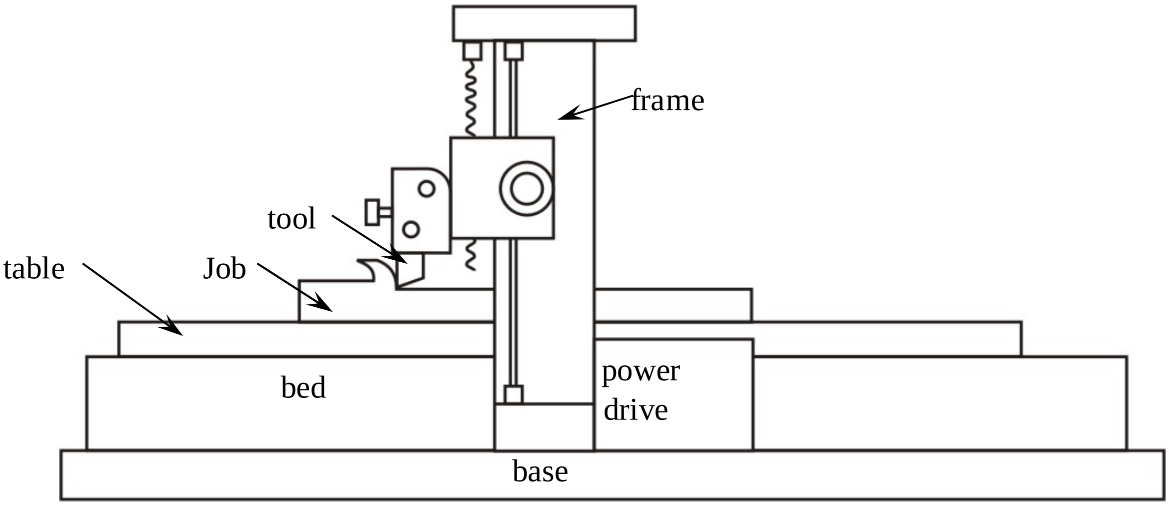


Fig. 2.12 *Schematic view of a planning machine*

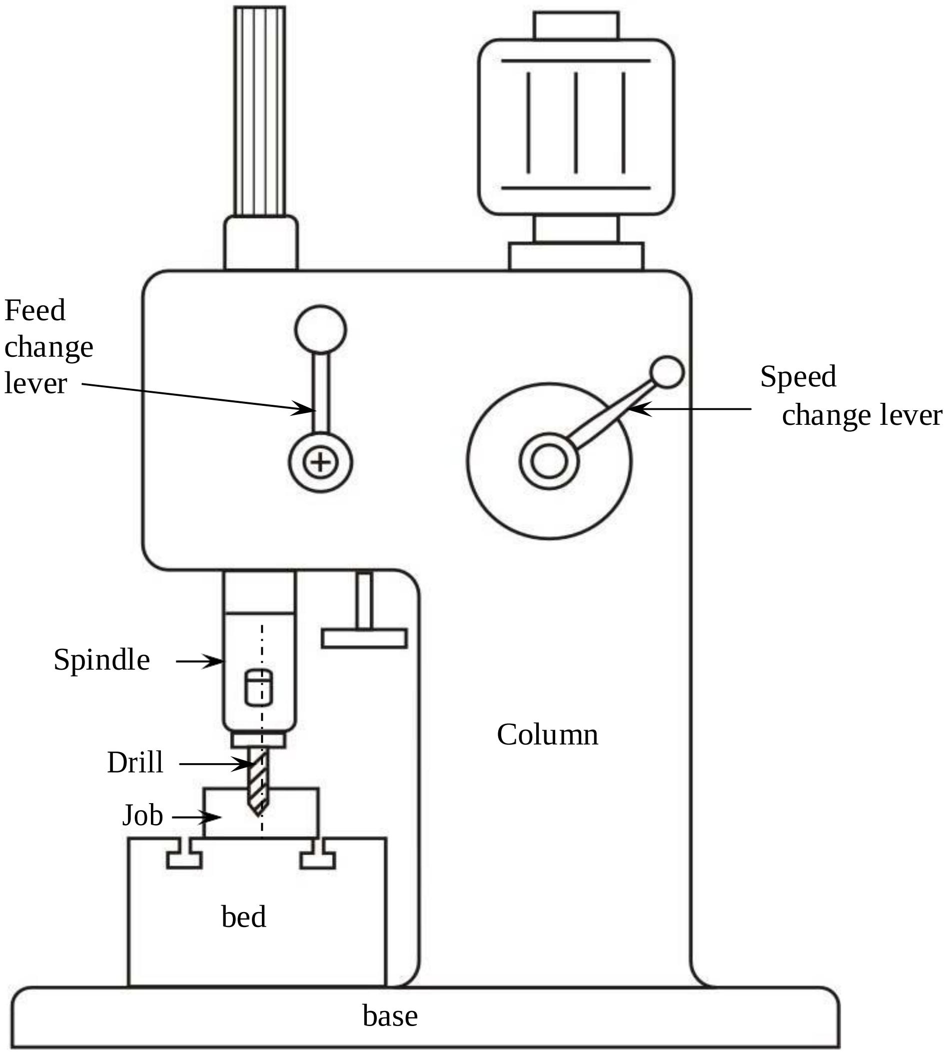


Fig. 2.13 *Schematic view of a drilling machine*

- **Milling machine**

  The general configuration of knee type conventional milling machine with horizontal arbour is shown in Fig. 2.14. Its major parts are
  - Milling arbour: to hold and rotate the cutter
  - Ram: to support the arbour
  - Machine table: on which job and job holding devices are mounted to provide the feed motions to the job.
  - Power drive with Speed and gear boxes: to provide power and motions to the tool-work
  - Bed: which moves vertically upward and downward and accommodates the various drive mechanisms
  - Column with base: main structural body to support other parts.

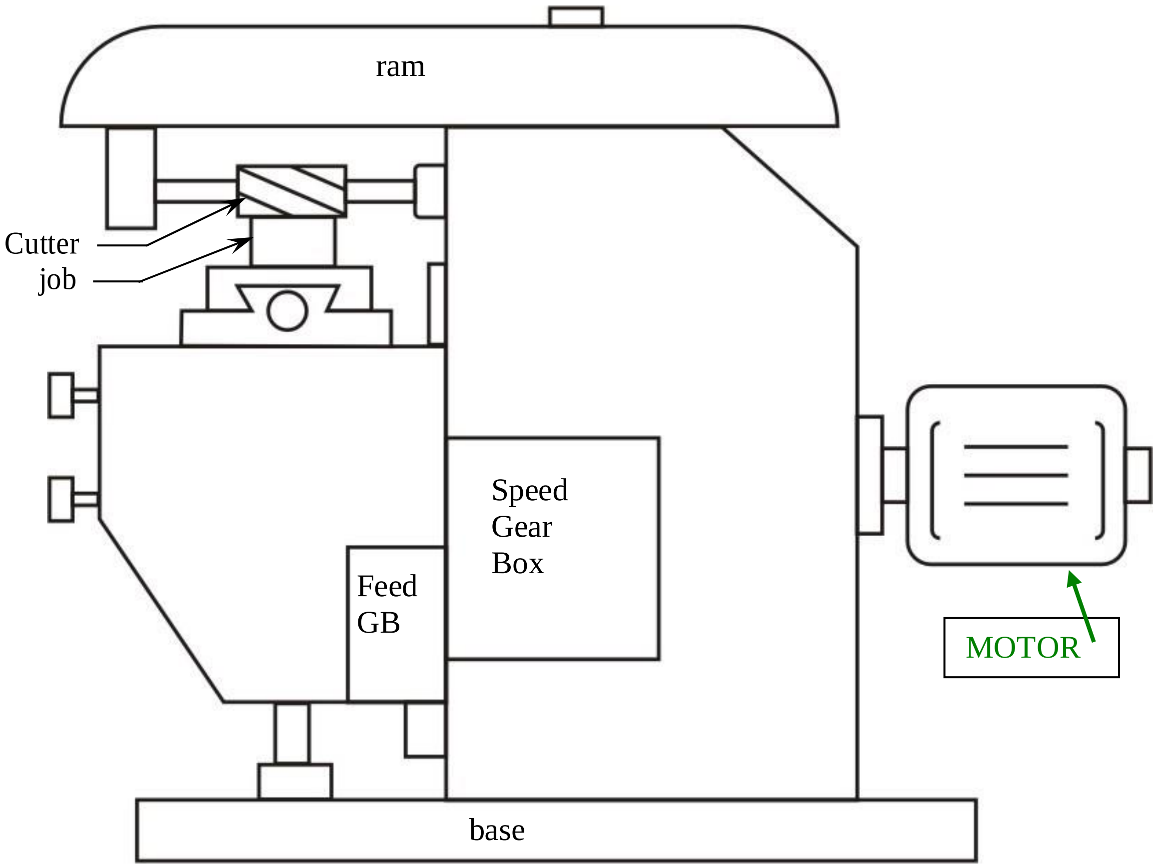


Fig. 2.14 *Schematic view of a milling machine*

Milling machines are also quite versatile and can do several operations like o making flat surfaces
- grooving, slitting and parting
- helical grooving

- forming 2-D and 3-D contoured surfaces

Fig. 2.15 shows some of the aforesaid milling operations.

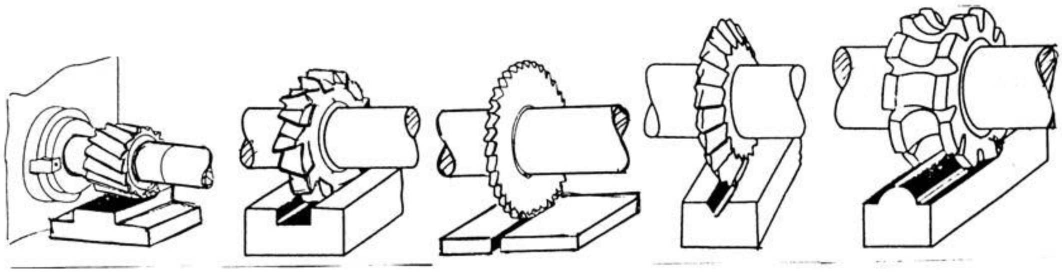


Fig. 2.15 *Some common milling operation*

Specification of Machine Tools.

A machine tool may have a large number of various features and characteristics. But only some specific salient features are used for specifying a machine tool. All the manufacturers, traders and users must know how are machine tools specified.

The methods of specification of some basic machine tools are as follows:

- **Centre lathe**
  - Maximum diameter and length of the jobs that can be accommodated
  - Power of the main drive (motor)
  - Range of spindle speeds
  - Range of feeds
  - Space occupied by the machine.

- **Shaping machine**
  - Length, breadth and depth of the bed
  - Maximum axial travel of the bed and vertical travel of the bed / tool
  - Maximum length of the stroke (of the ram / tool)
  - Range of number of strokes per minute
  - Range of table feed
  - Power of the main drive
  - Space occupied by the machine

- **Drilling machine (column type)**
  - Maximum drill size (diameter) that can be used
  - Size and taper of the hole in the spindle
  - Range of spindle speeds

- Range of feeds
- Power of the main drive
- Range of the axial travel of the spindle / bed
- Floor space occupied by the machine

- **Milling machine** (knee type and with arbour)
  - Type; ordinary or swiveling bed type
  - Size of the work table
  - Range of travels of the table in X-Y-Z directions
  - Arbour size (diameter)
  - Power of the main drive
  - Range of spindle speed
  - Range of table feeds in X-Y-Z directions
  - Floor space occupied.

Broad classification of Machine Tools

Number of types of machine tools gradually increased till mid 20th century and after that started decreasing based on Group Technology.
However, machine tools are broadly classified as follows:

- According to direction of major axis :
  - horizontal center lathe, horizontal boring machine etc.
  - vertical – vertical lathe, vertical axis milling machine etc.
  - inclined – special (e.g. for transfer machines).

- According to purpose of use :
  - general purpose – e.g. center lathes, milling machines, drilling machines etc.
  - single purpose – e.g. facing lathe, roll turning lathe etc.
  - special purpose – for mass production.

- According to degree of automation
  - non-automatic – e.g. center lathes, drilling machines etc.
  - semi-automatic – capstan lathe, turret lathe, hobbinh machine etc.
  - automatic – e.g., single spindle automatic lathe, swiss type automatic lathe, CNC milling machine etc.

- According to size :
  - heavy duty – e.g., heavy duty lathes (e.g. ≥ 55 kW), boring mills, planning machine, horizontal boring machine etc.
  - medium duty – e.g., lathes – 3.7 ~ 11 kW, column drilling machines, milling machines etc.
  - small duty – e.g., table top lathes, drilling machines, milling machines.
  - micro duty – e.g., micro-drilling machine etc.

- According to precision :

- ordinary – e.g., automatic lathes
- high precision – e.g., Swiss type automatic lathes

- According to number of spindles :
  - single spindle – center lathes, capstan lathes, milling machines etc.
  - multi-spindle – multispindle (2 to 8) lathes, gang drilling machines etc.

- According to blank type : o
  bar type (lathes)
  - chucking type (lathes)
  - housing type

- According to type of automation :
  - fixed automation – e.g., single spindle and multispindle lathes
  - flexible automation – e.g., CNC milling machine

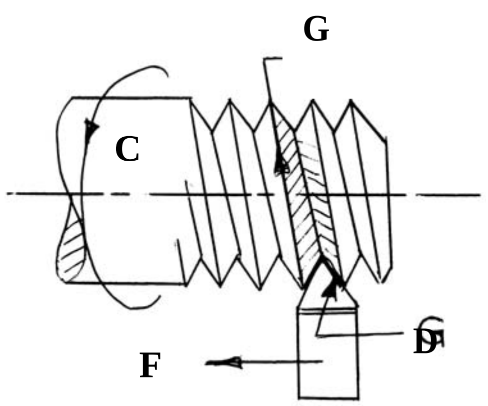
- According to configuration :
  - stand alone type – most of the conventional machine tools.
  - machining system (more versatile) – e.g., transfer machine, machining center, FMS etc.

Exercise – 2

1. Show the tool-work motions and the Generatrix and Directrix in external thread cutting in centre lathe. Also state how those 'G' & 'D' are obtained.
2. In which conventional machine tools flat surface can be produced ?
3. State the major differences between shaping machine and planing machine.
4. In which machine tools both the cutting motion & the feed motion are imparted to the tool ?
5. How is feed expressed in turning, shaping, drilling and milling ?

Answers

Ans. Q 1



G – x – T – F
D – (CM+FM) – (T+W) - T

Ans. Q. 2
Flat surfaces can be produced in

- centre lathes – e.g., facing
- shaping, slotting and planing machines
- milling machines

Ans. Q. 3

Shaping machine	Planing machine
o for small and medium size jobs	o for medium and large size jobs
o tool reciprocates and provide CM	o job on table reciprocates and provide CM
o feed motion is given to the job	o feed motion is given to the tool
o G – CM – T – Tr D – FM – W – Tr	o G – CM – W – Tr D – FM – T – Tr

Ans. Q. 4
Both CM and FM are imparted to the tool in

- drilling machine
- vertical boring machine

Ans. Q. 5

- turning – mm/rev
- shaping – mm/stroke
- drilling machine – mm/rev
- milling machine – mm/min

MODULE-II

ENGINE LATHE

Instructional objectives

At the end of this lesson, the students will be able to

(i) Name the general purpose machine tools of common use
(ii) Classify the different types of lathes
(iii) Illustrate the kinematic system of centre lathe and explain its method of working
(iv) State the different machining operations that are usually done in centre lathes.

(i) General Purpose Machine Tools Of Common Use

The basic machine tools which are commonly used for general purposes, are :

- Lathes
- Drilling machines
- Shaping machines
- Planning machines
- Slotting machines
- Milling machines
- Boring machines
- Hobbing machines
- Gear shaping machines
- Broaching machines
- Grinding machines

Each one of the machine tools, mentioned above, can be further classified into several types depending upon size, shape, automation, etc.

(ii) Classification Of Lathes

Lathes are very versatile of wide use and are classified according to several aspects:

(a) According to configuration

- Horizontal
  - Most common for ergonomic conveniences
- Vertical
  - Occupies less floor space, only some large lathes are of this type.

(b) According to purpose of use

- General purpose
  - Very versatile where almost all possible types of operations are carried out on wide ranges of size, shape and materials of jobs; example : centre lathes
- Single purpose

- Only one (occasionally two) type of operation is done on limited ranges of size and material of jobs; example – facing lathe, roll turning lathe etc.

- Special purpose
  - Where a definite number and type of operations are done repeatedly over long time on a specific type of blank; example: gear blank machining lathe etc.

(c) According to size or capacity

- Small (low duty)
  - In such light duty lathes (upto 1.1 kW), only small and medium size jobs of generally soft and easily machinable materials are machined
- Medium (medium duty)
  - These lathes of power nearly upto 11 kW are most versatile and commonly used
- Large (heavy duty)
- Mini or micro lathe
  - These are tiny table-top lathes used for extremely small size jobs and precision work; example : swiss type automatic lathe

(d) According to degree of automation

- Non-automatic
  - Almost all the handling operations are done manually; example: centre lathes
- Semi-automatic
  - Nearly half of the handling operations, irrespective of the processing operations, are done automatically and rest manually; example : capstan lathe, turret lathe, copying lathe relieving lathe etc.
- Automatic
  - Almost all the handling operations (and obviously all the processing operations) are done automatically; example – single spindle automat (automatic lathe), swiss type automatic lathe, etc.

(e) According to type of automation

- Fixed automation
  - Conventional; example – single spindle automat, swiss type automatic lathe etc.
- Flexible automation
  - Modern; example CNC lathe, turning centre etc.

(f) According to configuration of the jobs being handled

- Bar type
  - Slender rod like jobs being held in collets
- Chucking type
  - Disc type jobs being held in chucks

- Housing type

- Odd shape jobs, being held in face plate

(g) According to precision

- Ordinary
- Precision (lathes)
  - These sophisticated lathes meant for high accuracy and finish and are relatively more expensive.

(h) According to number of spindles

- Single spindle
  - Common
- Multispindle (2, 4, 6 or 8 spindles)
  - Such uncommon lathes are suitably used for fast and mass production of small size and simple shaped jobs.

(iii) Kinematic System And Working Principle Of Lathes

Amongst the various types of lathes, centre lathes are the most versatile and commonly used.

Fig. 4.1.1 schematically shows the typical kinematic system of a 12 speed centre lathe.

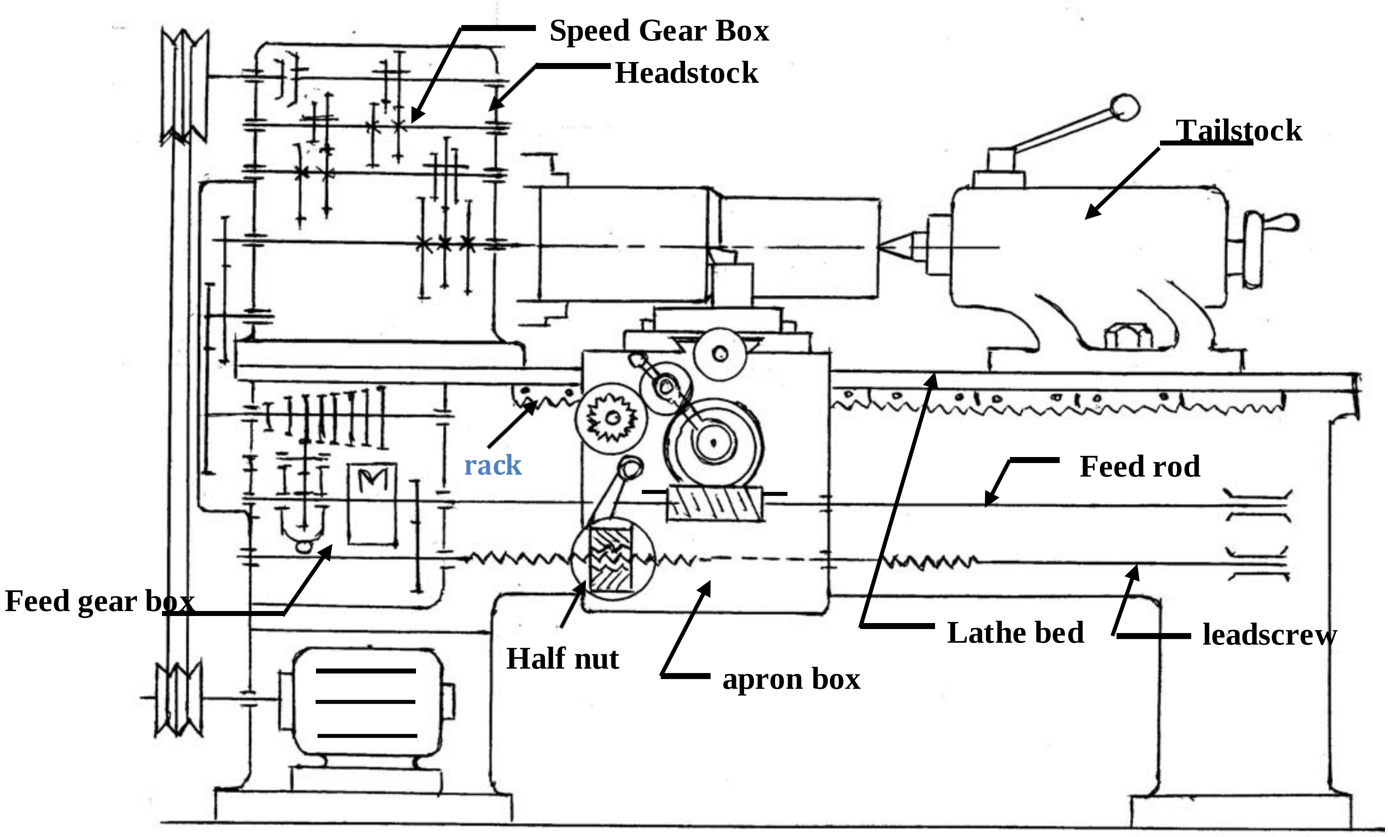


Fig. 4.1.1 *Schematic diagram of a centre lathe.*

For machining in machine tools the job and the cutting tool need to be moved relative to each other.

The tool-work motions are :

- Formative motions : - cutting motion
  - feed motion
- Auxiliary motions : - indexing motion
  - relieving motion etc

In lathes

- o Cutting motion is attained by rotating the job
- o Feed motion by linear travel of the tool
  - either axially for longitudinal feed
  - or radially for cross feed

It is noted, in general, from Fig. 4.1.1

- The job gets rotation (and power) from the motor through the belt-pulley, clutch and then the speed gear box which splits the input speed into a number (here 12) of speeds by operating the cluster gears.
- The cutting tool derives its automatic feed motion(s) from the rotation of the spindle via the gear quadrant, feed gear box and then the appron mechanism where the rotation of the feed rod is transmitted
  - either to the pinion which being rolled along the rack provides the longitudinal feed
  - or to the screw of the cross slide for cross or transverse feed.
- While cutting screw threads the half nuts are engaged with the rotating leadscrew to positively cause travel of the carriage and hence the tool parallel to the lathe bed i.e., job axis.
- The feed-rate for both turning and threading is varied as needed by operating the Norton gear and the Meander drive systems existing in the feed gear box (FGR). The range of feeds can be augmented by changing the gear ratio in the gear quadrant connecting the FGB with the spindle
- As and when required, the tailstock is shifted along the lathe bed by operating the clamping bolt and the tailstock quil is moved forward or backward or is kept locked in the desired location.
- The versatility or working range of the centre lathes is augmented by using several attachments like
  - Taper turning attachment
  - Thread milling attachment
  - Copying attachment

(iv) Machining Operations Usually Done In Centre Lathes

The machining operations generally carried out in centre lathes are :

- Facing
- Centering
- Rough and finish turning
- Chamfering, shouldering, grooving, recessing etc
- Axial drilling and reaming by holding the cutting tool in the tailstock barrel

- Taper turning by

- ↓ offsetting the tailstock
- ↓ swivelling the compound slide
- ↓ using form tool with taper over short length
- ↓ using taper turning attachment if available
- ↓ combining longitudinal feed and cross feed, if feasible.

- Boring (internal turning); straight and taper
- Forming; external and internal
- Cutting helical threads; external and internal
- Parting off
- Knurling

In addition to the aforesaid regular machining operations, some more operations are also occasionally done, if desired, in centre lathes by mounting suitable attachments available in the market, such as,

- Grinding, both external and internal by mounting a grinding attachment on the saddle
- Copying (profiles) by using hydraulic copying attachment
- Machining long and large threads for leadscrews, power-screws, worms etc. by using thread milling attachment.

Instructional objectives

At the end of this lesson, the students will be able to;

(i) Comprehend and state the use of accessories and attachments in machine tools
(ii) Realize and Identify why and when Attachments are necessarily used
(iii) Describe the basic construction and application principles of different attachments used in;

- Centre lathes
- Drilling machines
- Shaping machines
- Planing machines
- Milling machines

(i) Use Of Various Accessories And Attachments In General Purpose Machine Tools.

ACCESSORIES :

A general purpose machine tool is basically comprised of power drive and kinematic system for the essential formative and auxiliary tool – work motions and a rigid body or structure to accommodate all of the above. But several additional elements or devices called accessories are also essentially required for that machines' general functioning, mainly for properly holding and supporting the workpiece and the cutting tool depending upon the type and size of the tool – work and the machining requirements.

These accessories generally include for instance, in case of;

- Centre lathes : chucks, collets, face plate, steady and follower rests, centres, tool holders etc.
- Drilling machines : vices, clamps, drill chuck and sockets etc.
- Shaping and planning machines : vices, clamps, tool holders etc.
- Milling machines : vices, clamps, parallel blocks, collets, job – support like tailstock etc.

Such accessories, inevitable for general functioning of the machine tools, are usually enlisted in the supply list and covered within the total price of the machine tools. Occasionally, some accessories are ordered separately as and when required.

ATTACHMENTS

Each general purpose conventional machine tool is designed and used for a set of specific machining work on jobs of limited range of shape and size. But often some unusual work also need to be done in a specific machine tools, e.g. milling in a lathe, tapping in a drilling machine, gear teeth cutting in shaping machine and so on. Under such conditions, some special devices or systems are additionally used being mounted in the ordinary machine tools. Such additional special devices, which augment the processing capability of any ordinary machine tool, are known as Attachments, Unlike accessories, Attachments are not that inevitable and procured separately as and when required and obviously on extra payment. Some attachments being used in the general purpose conventional machine tools are :

- ***In centre lathes :***
  - Taper turning attachment
  - Copy turning attachments
  - Milling and cylindrical grinding attachments
  - Spherical turning attachments
  - Relieving attachment
- ***In drilling machines :***
  - Tapping attachment
- ***In shaping machines :***
  - Double cut tool head
  - Thread rolling attachment
  - Matterson's attachment (gear teeth cutting)
- ***In planing machines :***
  - Contour forming attachment
  - Helical grooving attachment
  - Oil grooving attachments
  - Milling and grinding attachments
- ***In Milling machines :***
  - universal milling attachment
  - indexing / dividing head
  - rotary table
  - slotting attachment

(ii) Conditions And Places Suitable For Application Of Attachments In Machine Tools.

With the rapid and vast advancement of science and technology, the manufacturing systems including machine tools are becoming more and more versatile and productive on one hand for large lot or mass production and also having flexible automation and high precision on the other hand required for production of more critical components in pieces or small batches. With the increase of versatility and precision (e.g., CNC machines) and the advent of dedicated high productive special purpose machines, the need of use of special attachments is gradually decreasing rapidly.

However, some attachments are occasionally still being used on non automatic general purpose machine tools in some small and medium scale machining industries;

- when and where machining facilities are very limited
- when production requirement is very small, may be few pieces
- product changes frequently as per job order
- repair work under maintenance, specially when spare parts are not available
- when CNC machine tools and even reasonable number of conventional machine tools cannot be afforded.

Therefore, use of aforesaid attachments is restricted to manufacture of unusual jobs in small quantities under limited facilities and at low cost.

(iii) Working Principles And Application Of Various Attachments In Different Machine Tools.

(a) Attachments used in centre lathes

- ***Taper turning attachment***

Taper cylindrical surface, which is a very common feature of several engineering components, is generally produced in lathes in a number of methods, depending upon length and angle of the tapered position of the job, such as offsetting tailstock, swivelling the compound slide using form tool and combined feed motions. But jobs with wide ranges of length and angle of taper, are easily machined by using a simple attachment, called taper turning attachment. Fig. 4.6.1 schematically shows a taper turning attachment where the cross slide is delinked from the saddle and is moved crosswise by the guide block which moves along the guide bar preset at the desired taper angle. Thus, the cutting tool, which is fitted on the cross slide through the tool post and the compound slide, also moves along with the guide black in the same direction resulting the desired taper turning.

- ***Copy turning attachment***

There are two common types of copy turning;

- mechanical type
- hydraulic type

o ***Mechanical copying***

A simple mechanical type copy turning attachment has been schematically shown in Fig. 4.6.2. The entire attachment is mounted on the saddle after removing the cross slide from that. The template replicating the job-profile desired is clamped at a suitable position on the bed. The stylus is fitted in the spring loaded tool slide and while travelling longitudinally along with saddle moves in transverse direction according to the template profile enabling the cutting tool produce the same profile on the job as indicated in the Fig. 4.6.2

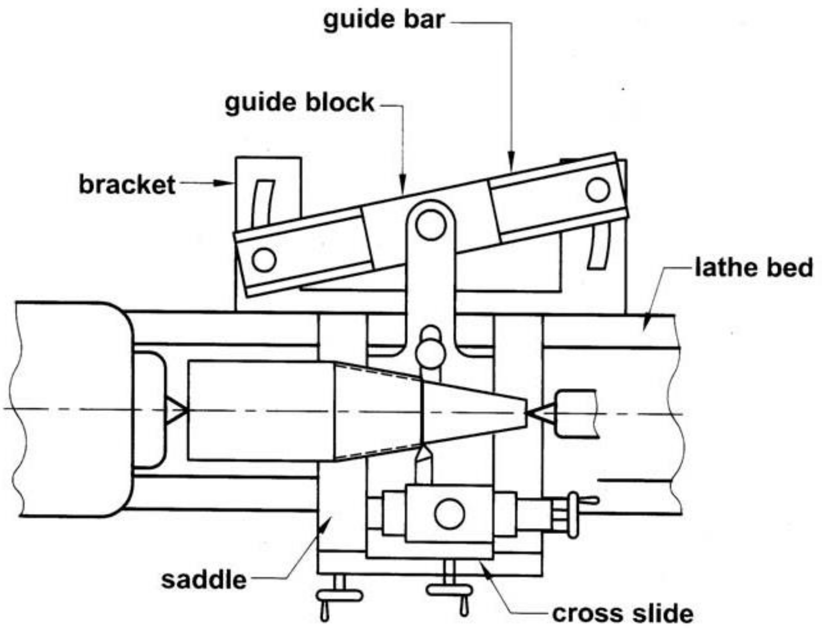


Fig. 4.6.1 *Taper turning attachment.*

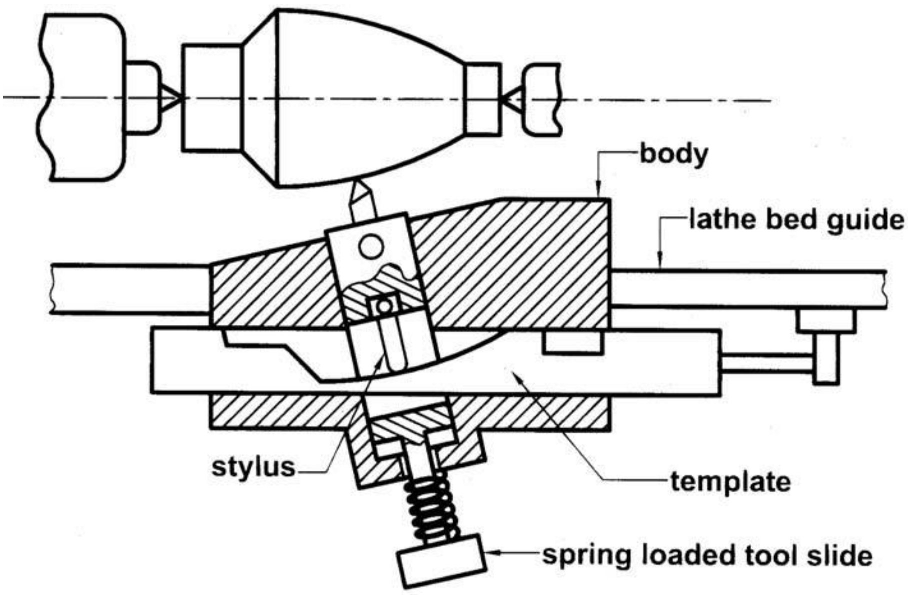


Fig. 4.6.2 *Mechanical type copying attachment.*

o *Hydraulic copying attachment*

The mounting and working principle of hydraulic copying attachment for profile turning in centre lathe are schematically shown in Fig. 4.6.3. Here also, the stylus moves along the template profile to replicate it on the job. In mechanical system (Fig. 4.6.2) the heavy cutting force is transmitted at the tip of the stylus, which causes vibration, large friction and faster wear and tear. Such problems are almost absent in hydraulic copying, where the stylus works simply as a valve – spool against a light spring and is not affected by the cutting force. Hydraulic copying attachment is costlier than the mechanical type but works much smoothly and accurately. The cutting tool is rigidly fixed on the cross slide which also acts as a valve – cum – cylinder as shown. So long the stylus remains on a straight edge parallel to the lathe bed, the cylinder does not move transversely and the tool causes straight turning. As soon as the stylus starts moving along a slope or profile, i.e., in cross feed direction the ports open and the cylinder starts moving accordingly against the piston fixed on the saddle. Again the movement of the cylinder i.e., the slide holding the tool, by same amount travelled by the stylus, and closes the ports. Repeating of such quick incremental movements of the tool, ⊗x and ⊗y result in the profile with little surface roughness.

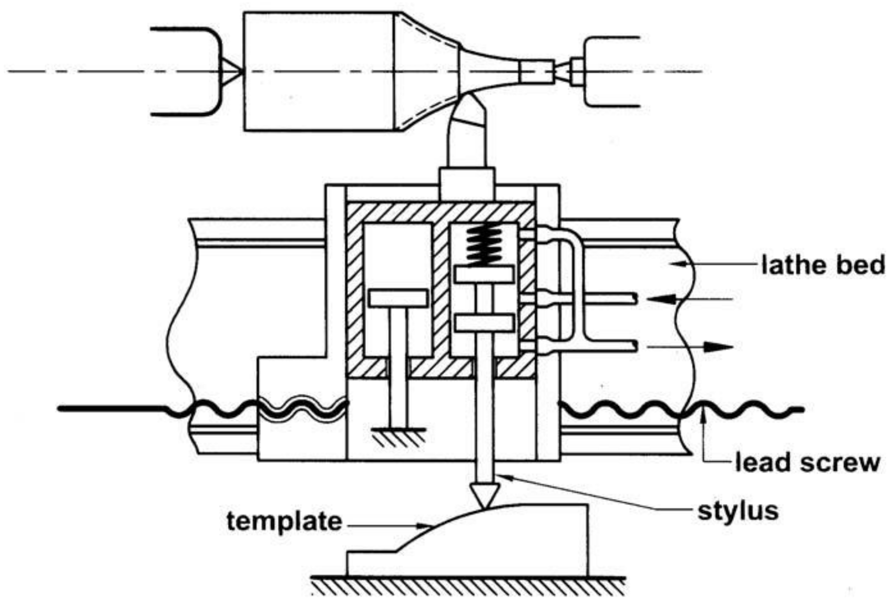


Fig. 4.6.3 Hydraulic copying attachment.

- *Milling attachment*

This is a milling head, comprising a motor, a small gear box and a spindle to hold the milling cutter, mounted on the saddle after removing the cross slide etc. as shown in Fig. 4.6.4. Milling attachments are generally used for making flat surfaces, straight and helical grooves, splines, long and deep screw threads, worms etc. in centre lathes by using suitable milling cutters.

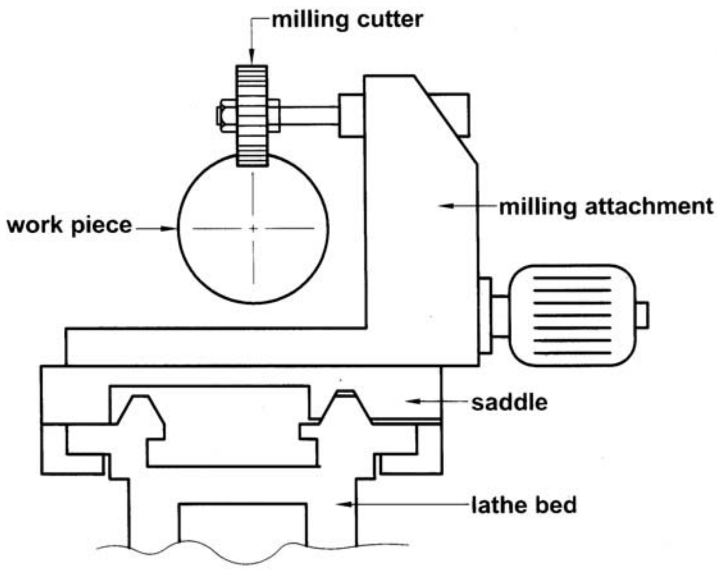


Fig. 4.6.4 *Milling attachment used in lathe.*

- ***Grinding attachment***

Grinding attachment is very similar to milling attachment. But in the former, there is no gear box and the spindle speed is much higher as needed for grinding operation. Such attachments are employed for external and internal cylindrical grinding, finishing grooves, splines etc. and also for finish grinding of screw threads in centre lathe. But unlike dedicated machines, attachments cannot provide high accuracy and finish.

- ***Spherical turning attachments***

These simple attachments are used in centre lathes for machining spherical; both convex and concave surfaces and similar surfaces. Fig. 4.6.5 schematically visualises the usual setting and working principle of such attachments. In Fig. 4.6.5 (b), the distance R_i can be set according to the radius of curvature desired. In the type shown in Fig. 4.6.5 (a) the desired path of the tool tip is controlled by the profile of the template which is pre- made as per the radius of curvature required. The saddle is disconnected from the feed rod and the leadscrew. So when the cross slide is moved manually in transverse direction, the tool moves axially freely being guided by the template only.

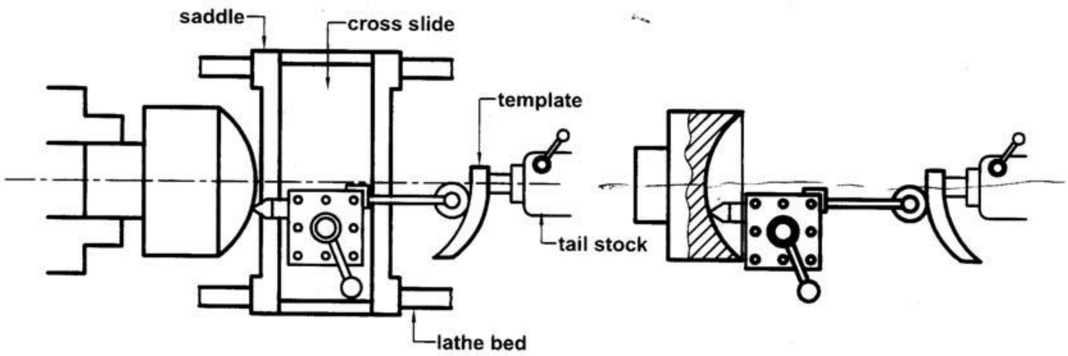


Fig. 4.6.5 *(a) Spherical turning using template.*

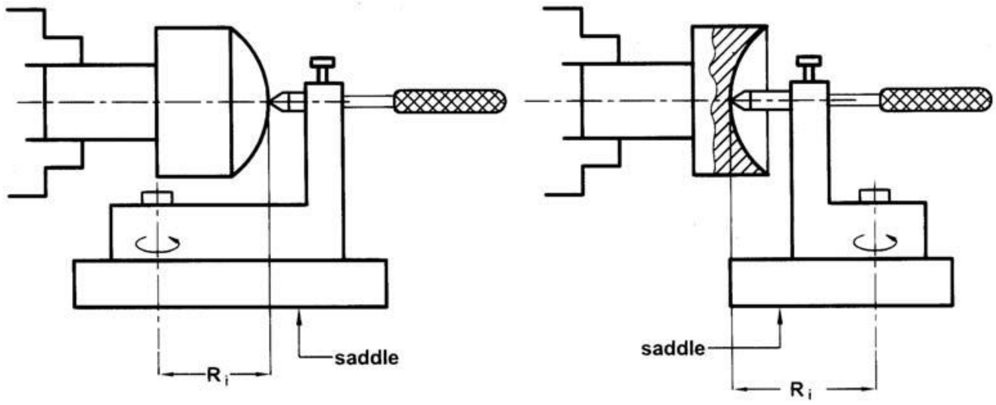
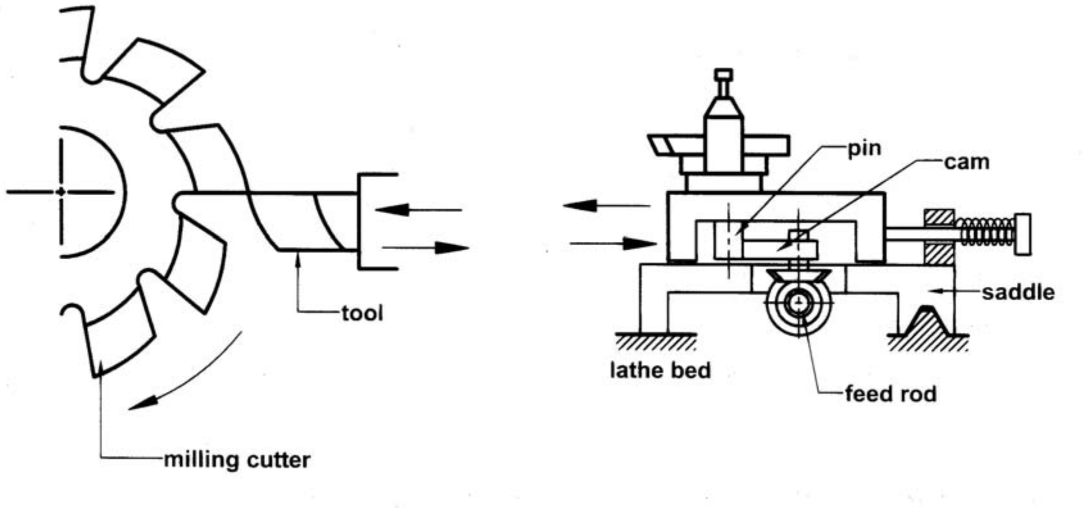


Fig. 4.6.5 *(b) Spherical turning without template.*

- ***Relieving attachment***

The teeth of form relieved milling cutters like gear milling cutters, taps, hobs etc. are provided with flank having archemedian spiral curvature. Machining and grinding of such curved flanks of the teeth need relieving motion to the tool (or wheel) as indicated in Fig. 4.6.6 (a). The attachment schematically shown in Fig. 4.6.6 (b) is comprised of a spring loaded bracket which holds the cutting tool and is radially reciprocated on the saddle by a plate cam driven by the feed rod as indicated.



(a) (b)

Fig. 4.6.6 *Relieving attachment used in lathe.*

- ***Thread pitch correcting attachment***

While cutting screw thread in centre lathes by single point chasing tool, often the actual pitch, p_a deviates from the desired (or stipulated) pitch, p_s by an error (say $\pm \otimes p$) due to some kinematic error in the lathe.
Mathematically,

$$p_s - p_a = \pm \otimes p \qquad (4.6.1)$$

Therefore for correct pitch, the error $\pm \otimes p$ need to be compensated and this may be done by a simple differential mechanism, namely correcting bar attachment as schematically indicated in Fig. 4.6.7.
In equation 4.6.1,

$$p_a = 1 \times U_C \times L$$

$$\pm \otimes p = p_s \tan(\pm\alpha).L/(\pi m Z) \qquad (4.6.2)$$

where, U_C = transmission ratio
L = lead of the leadscrew
m, Z = module and no. of teeth of the gear fixed with the nut and is additionally rotated slightly by the movement of the rack along the bar.

Such differential mechanism of this attachment can also be used for intentionally cutting thread whose pitch will be essentially slightly more or less than the standard pitch, as it may be required for making differential screws having threads of slightly different pitch at two different locations of the screw.

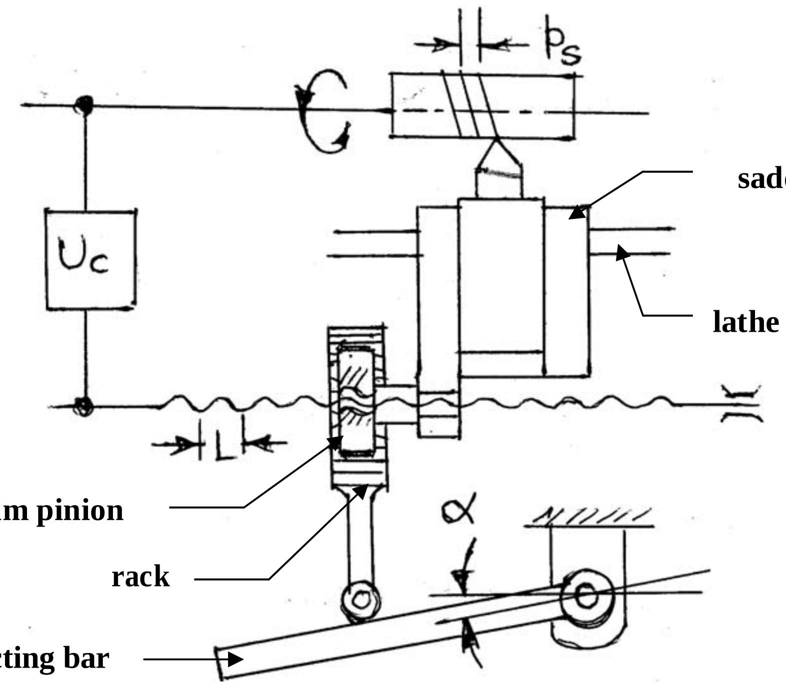
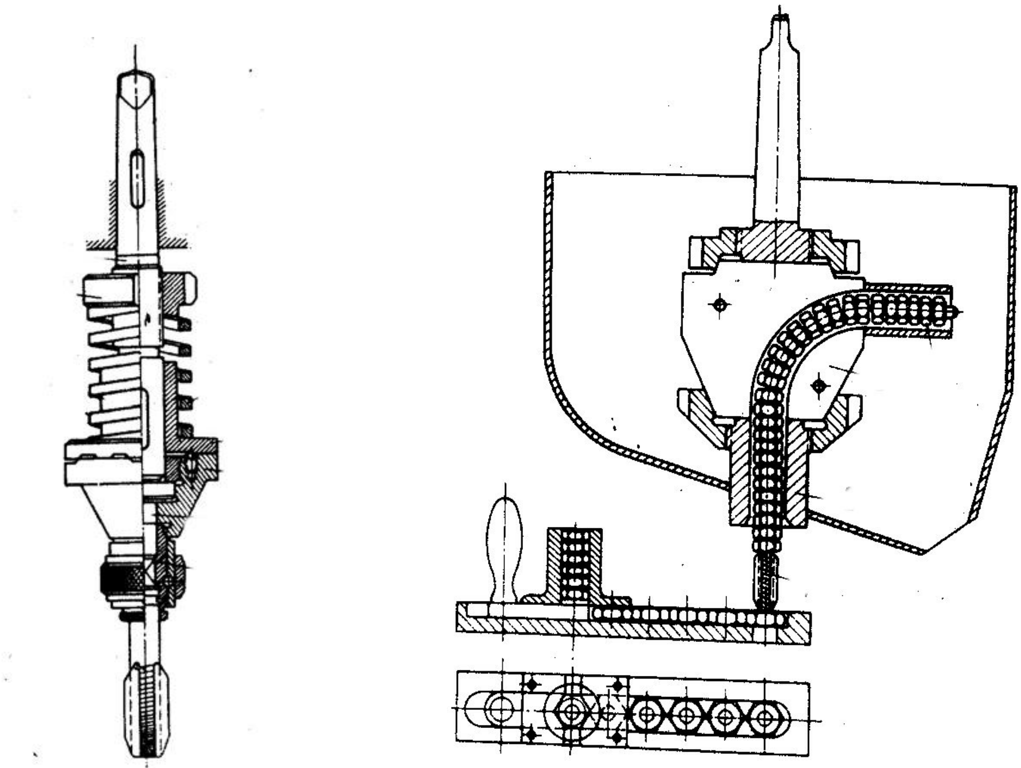


Fig. 4.6.7 *Thread pitch correcting attachment.*

(b) Attachments used in drilling machines

o ***Tapping attachment***

It has been mentioned earlier in the previous lessons that several machining work other than drilling can be done in drilling machine using different types of cutting tools and job holding device. Tapping of nuts for their internal threads is also often done in a drilling machine by using tapping attachment as schematically shown in Fig. 4.6.8. Return of the tap by reverse rotation of the spindle without damage of the thread and the tap is the most critical design. Fig. 4.6.8 (a) visualises that the spring loaded sliding clutch engages with the free tapping clutch during threading. The clearance between the jaws of the two clutches and the spring action enable safe return of the tap following that of the spindle. Fig. 4.6.8 (b) shows another faster working tapping system where the hexagonal blanks are fed one by one and the tapping unit, rotating at a constant speed in the same direction moves only up and down for ejecting the threaded nuts by centrifugal force.



(a) (b)

Fig. 4.6.8 *Tapping attachment used in drilling machine.*

(c) Attachments used in shaping machine

Some attachments are often used for extending the processing capabilities of shaping machines and also for getting some unusual work in ordinary shaping machine.

- ***Attachment for double cut***

This simple attachment is rigidly mounted on the vertical face of the ram replacing the clapper box. It is comprised of a fixed body with two working flat surfaces and a swing type tool holder having two tools on either faces as can be seen in Fig. 4.6.9. The tool holder is tilted by a spring loaded lever which is moved by a trip dog at the end of its strokes.
Such attachment simply enhances the productivity by utilising both the strokes in shaping machines.

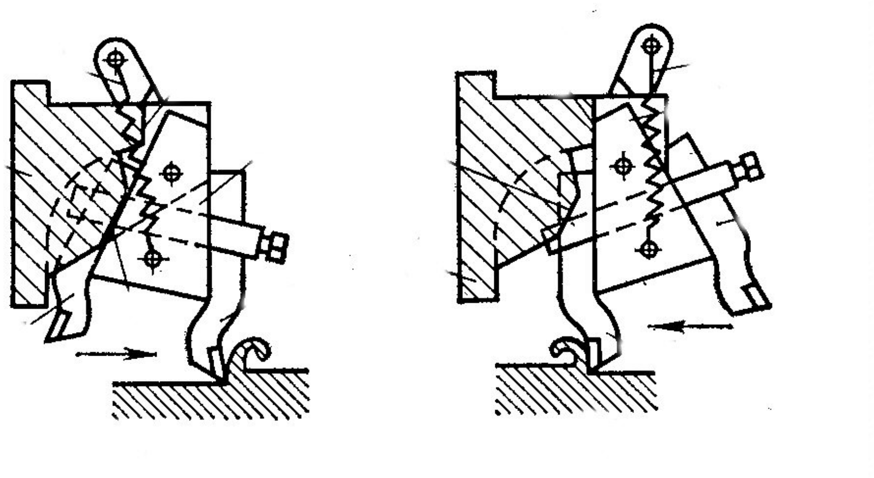


Fig. 4.6.9 *Double cut attachment used in shaping machine.*

- ***Thread rolling attachment***

The thread of fasteners is done by mass production methods. Thread rolling is hardly done nowadays in shaping machines. However the configuration, mounting and the working principle of the thread rolling (in shaping machine) attachment are visualised in Fig. 4.6.10. In between the flat dies, one fixed and one reciprocating, the blanks are pushed and thread – rolled one byone.

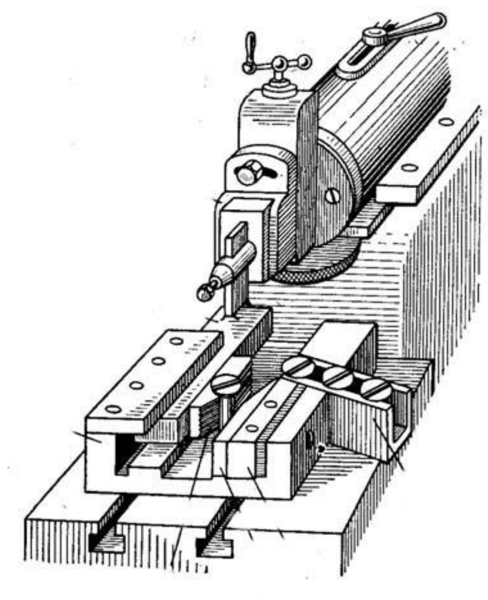


Fig. 4.6.10 *Thread rolling attachment used in shaping machine.*

- ***Matterson's attachment***

Various machines and processes have been developed for producing gear teeth with high productivity and job quality. Gear teeth are hardly produced nowadays in shaping machines. But, if required, it may be occasionally done by shaping machine in some small tool room or small workshop specially for repair and maintenance work. One or two, even all the teeth of a gear may be cut by forming tool in shaper using an indexing head. But such forming, specially in shaper is not only very slow process but also not at all accurate. But the Matterson's attachment can produce gear (spur) teeth even in shaping machine by generation process. The working principle of the attachment is shown in Fig. 4.6.11. For generation of the tooth by rolling the blank is rotated and the bed is travelled simultaneously at same linear speed by the synchronised kinematics as indicated in the diagram. After completing one tooth gap both the tool and blank are returned to their initial positions and then after indexing the blank for one tooth, the tool – work motions are repeated.

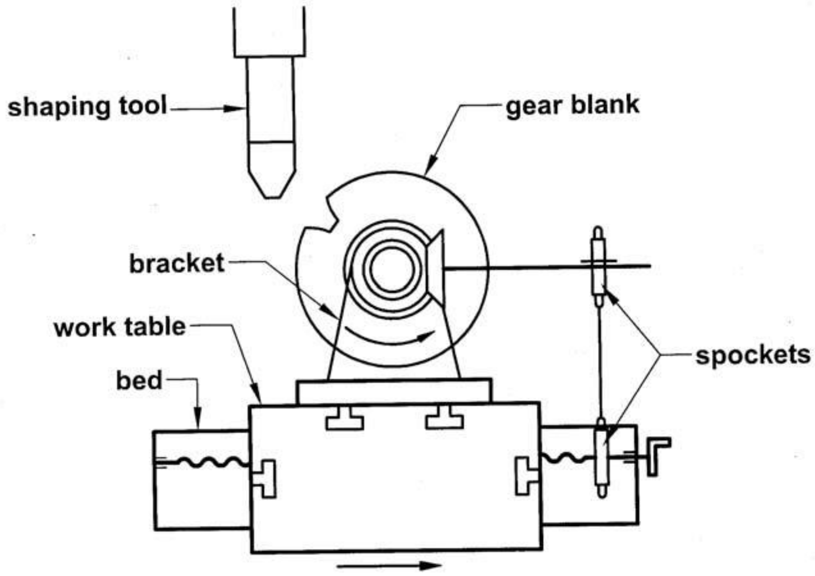
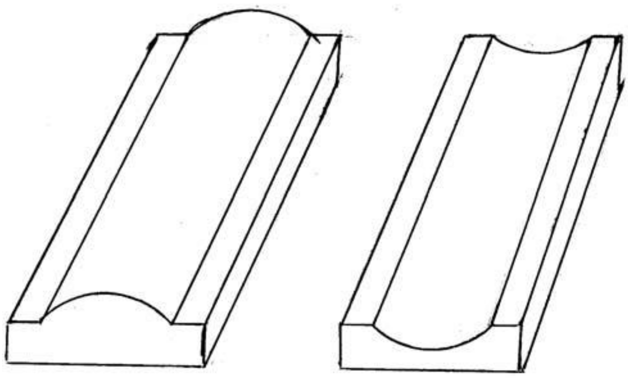


Fig. 4.6.11 *Matterson's Attachment for gear teeth generation in shaping machine.*

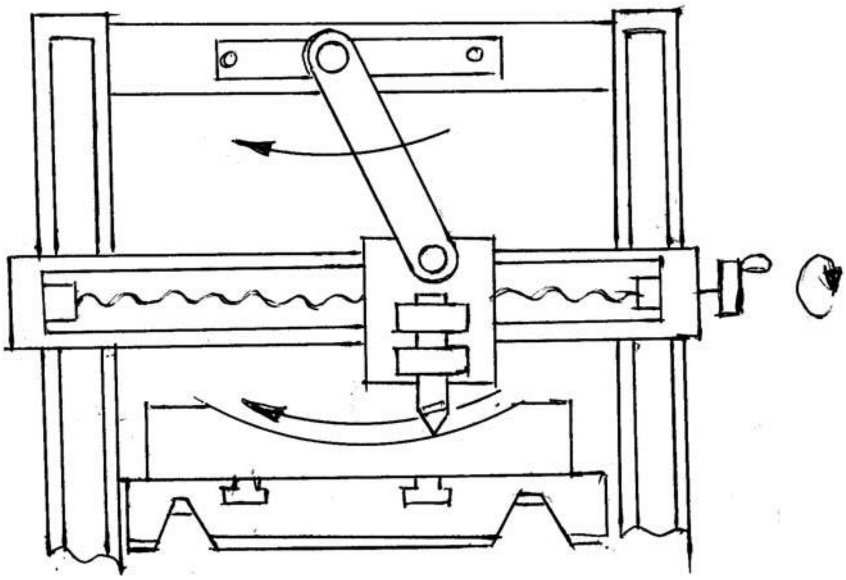
(d) Attachments used in planing machines

- ***Contour forming attachment***

This simple and low cost attachment may be used in planing macvhine for producing 2 – D form of circular section in long heavy tables or beds as indicated in Fig. 4.6.12 (a). The basic working principle is schematically shown in Fig. 4.6.12 (b). The convex circular arc form is produced by a swinging bar hinged at the upper bracket and connected with one tool head which is manually or automatically moved axially by the horizontal leadscrew. The horizontal rail is kept delinked from the vertical leadscrews. The horizontal feed alone will move the tool – tip in circular path with the help of the swing – bar. Similarly, with slight modification the concave form can also be made.



(a)



(b)

Fig. 4.6.12 *Contour forming attachment used in planning machine.*

- ***Helical grooving attachment***

Long lead helical grooves on large rod type jobs can be done easily and inexpensively in a planing machine, if available, by using simple attachment as shown in Fig. 4.6.13. Swinging of the bar clamping the linearly travelling rod (job) due to the prefixed inclined bar causes the required rotation of the rod. Such rotation along with linear axial travel produce the groove.

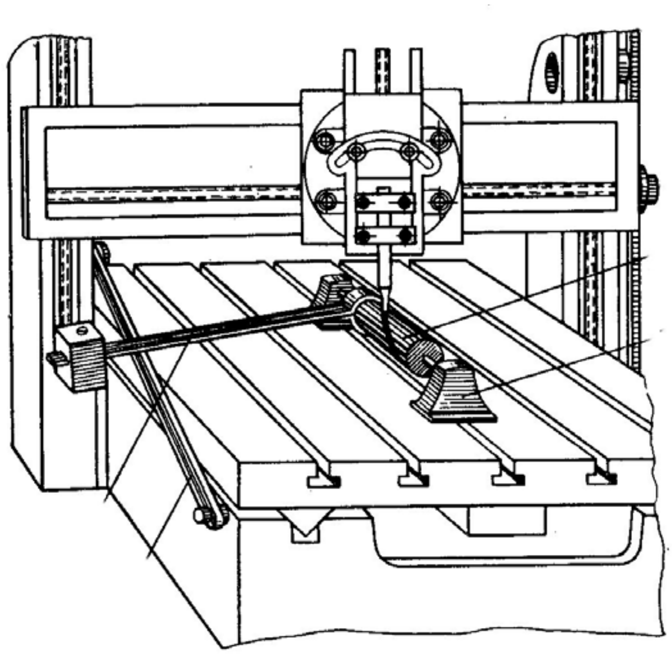


Fig. 4.6.13 *Attachment in planing machine for cutting long lead helical grooves.*

- ***Other attachments used in planing machine***
  - ⊗ Shallow oil grooves of various patterns can be cut on the flat surfaces of large tables or beds of large machineries by replacing the stationary fixed single point tool (s) by a rotary tool driven by a separate motor.
  - ⊗ Hydraulic tracer control type attachments are often used for making complex shaped 2 – D contours on large components in planing machines. The form of the template is replicated on the product as described in case of hydraulic copying lathe.
  - ⊗ Milling and grinding attachments.

    Both productivity and process capability of conventional planing machines are low for use of single point tools. Both productivity and finish are substantially increased by replacing those single point tool heads by milling and grinding heads on the horizontal and / or vertical rails. Such powered heads with rotary tools led to development of high productive plano millers and plano grinders.

(e) Attachments used in Milling machines

- ***Universal milling attachment***

Amongst the knee type conventional milling machines, horizontal arbour type is very widely used, where various types and sizes of milling cutters viz. plain or slab milling cutters and disc type cutters including single and double side(s) cutter, slot cutter, form cutters, gear milling cutters, slitting cutter etc. having axial bore are mounted on the horizontal arbour. For milling by solid end mill type and face milling cutters, separate vertical axis type milling machines are available. But horizontal arbour type milling machines can also be used for those operations to be done by end milling and smaller size face milling cutters by using proper attachments. The universal milling attachment is shown in Fig. 4.6.14. The rotation of the horizontal spindle is transmitted into rotation about vertical and also in any inclined direction by this attachment which thus extends the processing capabilities and application range of the milling machine.

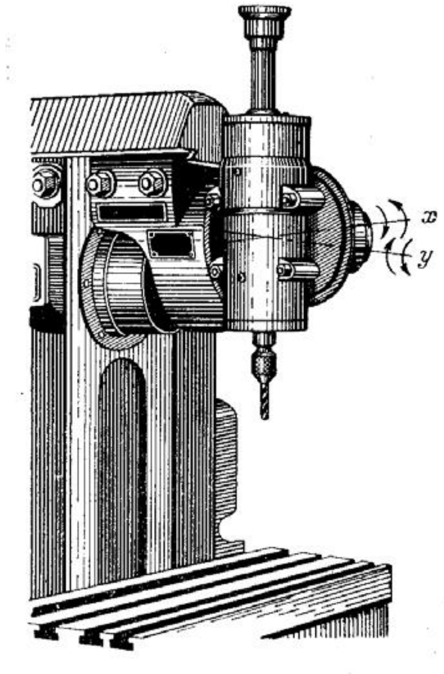


Fig. 4.6.14 *Universal milling attachment.*

- ***Indexing or Dividing head***

This device is essentially so frequently and widely needed and used that it is also considered as an accessory. But it is taken as an attachment possibly for being procured separately. This attachment is basically used for equi-angular rotation by simple compound or differential indexing of the job while machining. Fig. 4.6.15 typically shows a universal type dividing head and its mounting and an application.

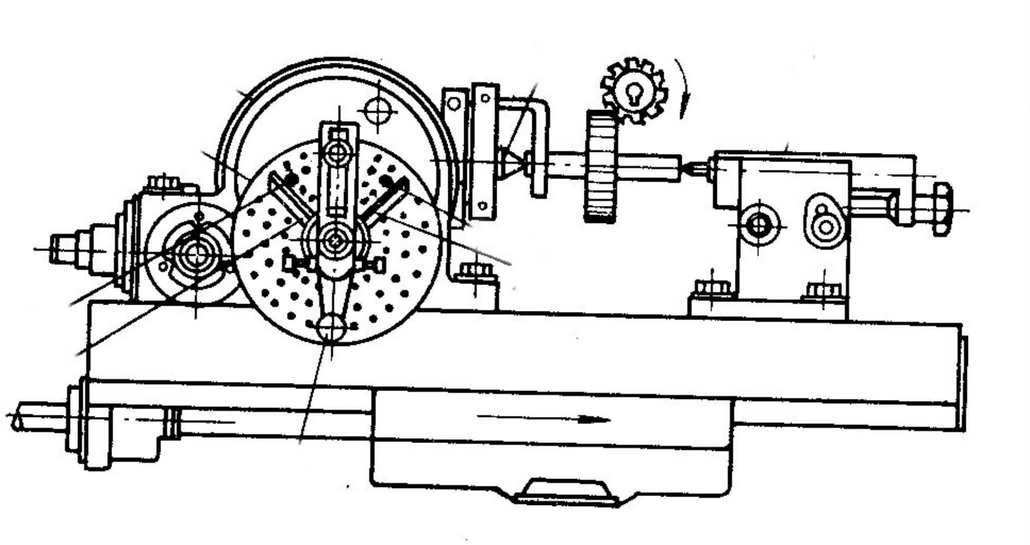


Fig. 4.6.15 *A Universal type dividing head and its application.*

- ***Rotary table***

This device may also be considered both accessory or attachment and is generally used in milling machines for both offline and online indexing / rotation of the job, clamped on it, about vertical axis. Fig. 4.6.16 visualises such a rotary table which is clamped or mounted on the machine bed /table.

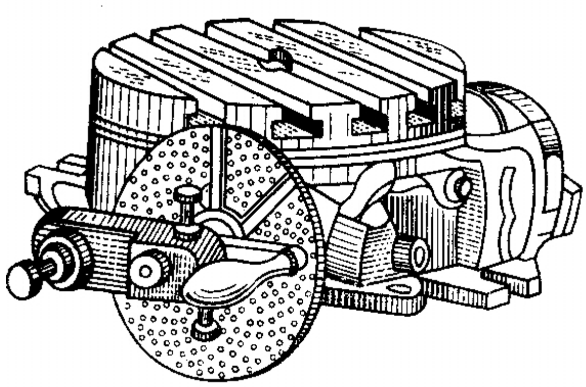


Fig. 4.6.16 *A rotary table which can be clamped or mounted on the machine bed.*

- ***Slotting attachment***

Such simple and low cost attachment is mounted on the horizontal spindle for producing keyways and contoured surface requiring linear travel of single point tool in milling machine where slotting machine and broaching machine are not available. The configuration of such a slotting attachment and its mounting and operation can be seen in Fig. 4.6.17. The mechanism inside converts rotation of the spindle into reciprocation of the single point tool in vertical direction. The direction of the tool path can also be tilted by swivelling the circular base of the attachment body.

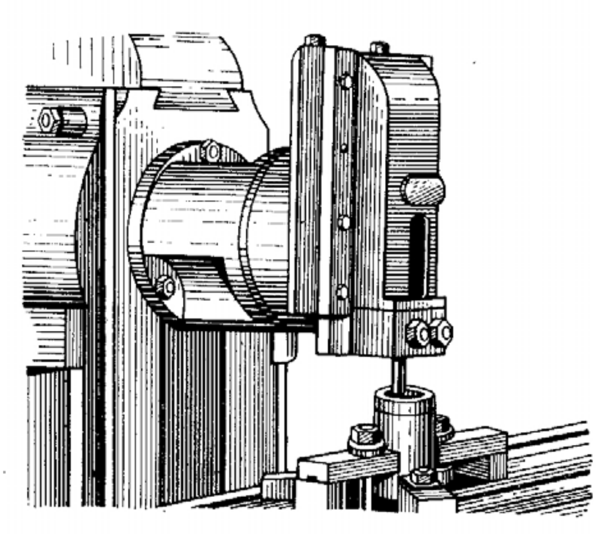


Fig. 4.6.17 *Slotting attachment*

There are several other possible attachments which can be used for some specific application not included in the basic range of a particular machine tool. New attachments can also be developed if so demanded. But need and use of attachments are gradually decreasing for rapid and vast developments in types of machine tools and more so after the advent of CNC machine tools with flexible automation.

MODULE-III

SHAPER,SLOTTER AND PLANNER: DRILLING AND BORING

Instructional objectives

At the end of this lesson, the students will be able to;

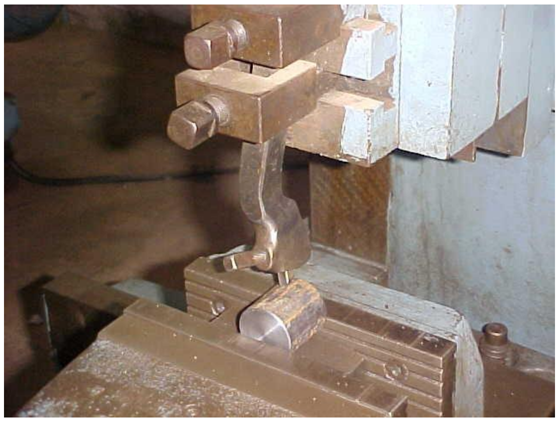
(i) Demonstrate the configurations and functions of shaping machine, planing machine and slotting machine
(ii) Illustrate the kinematic systems and explain the working principles of shaping machine, planing machine and slotting machine
(iii) Show and describe the various machining applications of shaping, planing and slotting machines.

(i) Configurations and basic functions of

- **Shaping machines**
- **Planing machines**
- **Slotting machines**

- **Shaping machine**

A photographic view of general configuration of shaping machine is shown in Fig. 4.4.1. The main functions of shaping machines are to produce flat surfaces in different planes. Fig. 4.4.2 shows the basic principle of generation of flat surface by shaping machine. The cutting motion provided by the linear forward motion of the reciprocating tool and the intermittent feed motion provided by the slow transverse motion of the job along with the bed result in producing a flat surface by gradual removal of excess material layer by layer in the form of chips. The vertical infeed is given either by descending the tool holder or raising the bed or both. Straight grooves of various curved sections are also made in shaping machines by using specific form tools. The single point straight or form tool is clamped in the vertical slide which is mounted at the front face of the reciprocating ram whereas the workpiece is directly or indirectly through a vice is mounted on the bed.



Cutting tool in action

Fig. 4.4.1 *Photographic view of a shaping machine*

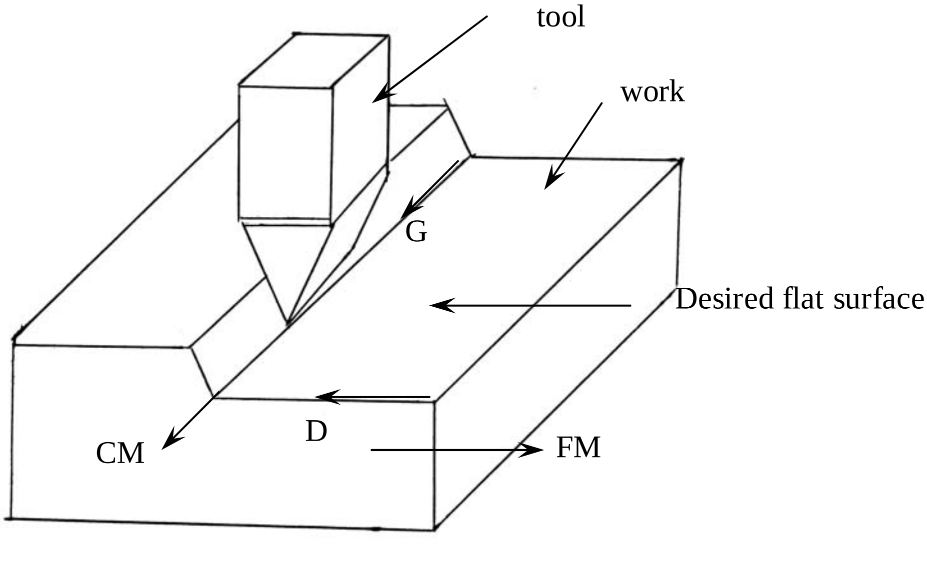


Fig. 4.4.2 *Principle of producing flat surface in shaping machine*

- **Planing machine**

The photographic view in Fig. 4.4.3 typically shows the general configuration of planing machine. Like shaping machines, planing machines are also basically used for producing flat surfaces in different planes. However, the major differences between planing machines from shaping machines are :

- o Though in principle both shaping and planing machines produce flat surface in the same way by the combined actions of the Generatrix and Directrix but in planing machine, instead of the tool, the workpiece reciprocates giving the fast cutting motion and instead of the job, the tool(s) is given the slow feed motion(s).
- o Compared to shaping machines, planing machines are much larger and more rugged and generally used for large jobs with longer stroke length and heavy cuts. In planing machine, the workpiece is mounted on the reciprocating table and the tool is mounted on the horizontal rail which, again, can move vertically up and down along the vertical rails.
- o Planing machines are more productive (than shaping machines) for longer and faster stroke, heavy cuts (high feed and depth of cut) possible and simultaneous use of a number of tools.

As in shaping machines, in planing machines also;

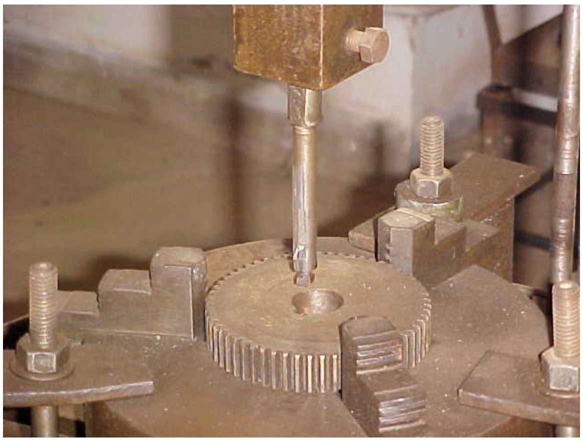
- ⊗ The length and position of stroke can be adjusted
- ⊗ Only single point tools are used
- ⊗ The quick return persists
- ⊗ Form tools are often used for machining grooves of curved section
- ⊗ Both shaping and planing machines can also produce large curved surfaces by using suitable attachments.

Cutting tool in action

Fig. 4.4.3 *Photographic view of a planing machine*

- **Slotting machine**

Slotting machines can simply be considered as vertical shaping machine where the single point (straight or formed) reciprocates vertically (but without quick return effect) and the workpiece, being mounted on the table, is given slow longitudinal and / or rotary feed as can be seen in Fig. 4.4.4. In this machine also the length and position of stroke can be adjusted. Only light cuts are taken due to lack of rigidity of the tool holding ram for cantilever mode of action. Unlike shaping and planing machines, slotting machines are generally used to machine internal surfaces (flat, formed grooves and cylindrical).
Shaping machines and slotting machines, for their low productivity, are generally used, instead of general production, for piece production required for repair and maintenance. Like shaping and slotting machines, planing machines, as such are also becoming obsolete and getting replaced by plano- millers where instead of single point tools a large number of large size and high speed milling cutters are used.



Cutting tool in action

Fig. 4.4.4 *Photographic view of a slotting machine*

(ii) Kinematic system and working principles of

- Shaping machine
- Planing machine
- Slotting machine

- **Shaping machine**

The usual kinematic system provided in shaping machine for transmitting power and motion from the motor to the tool and job at desired speeds and feeds is schematically shown in Fig. 4.4.5.

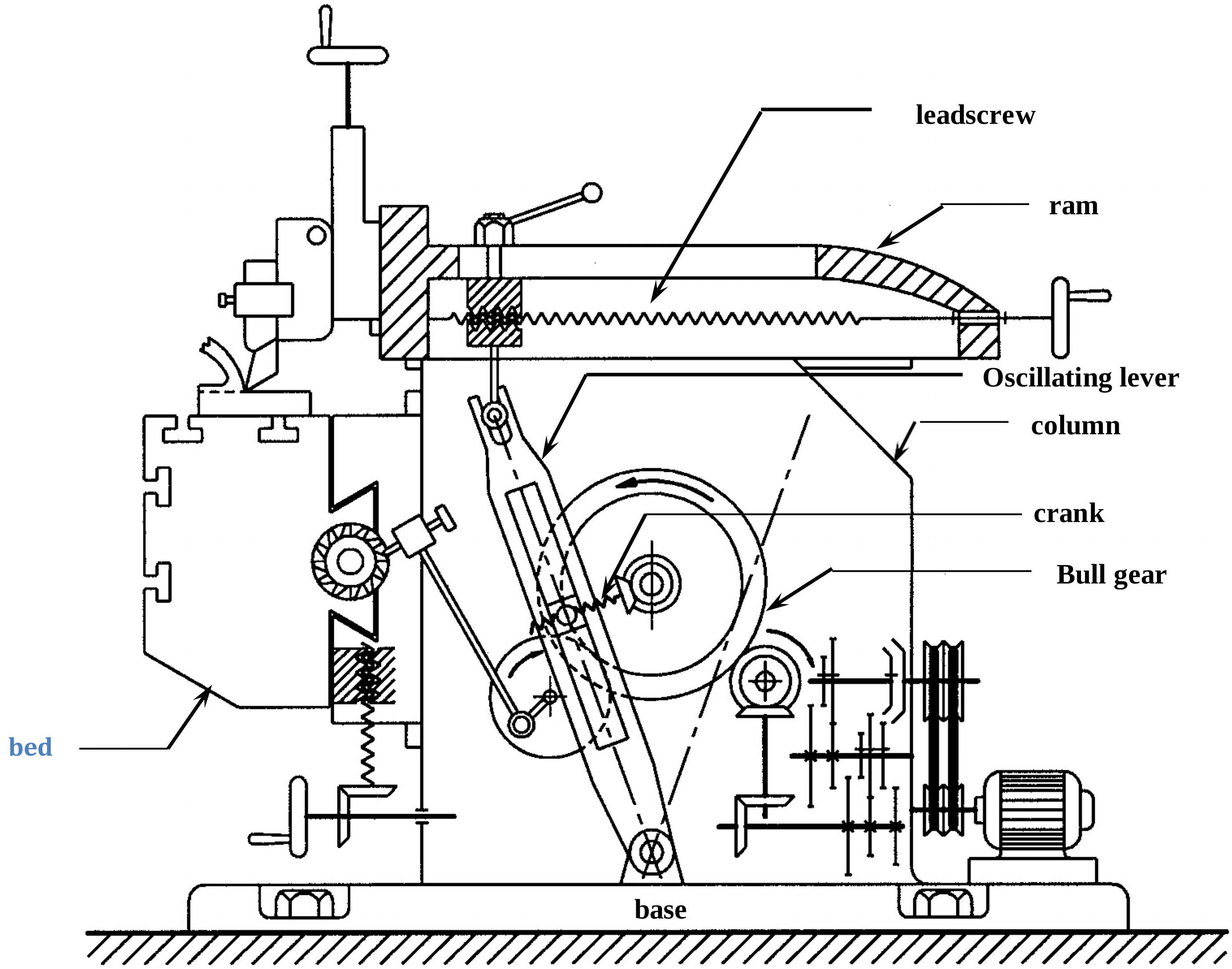


Fig. 4.4.5 *Kinematic diagram of a shaping machine.*

The central large bull gear receives its rotation from the motor through the belt-pulley, clutch, speed gear box and then the pinion. The rotation of the crank causes oscillation of the link and thereby reciprocation of the ram and hence the tool in straight path. Cutting velocity which needs to be varied depending upon the tool-work materials, depends upon

- The stroke length, S mm
- Number of strokes per min., N_s and
- The Quick return ratio, QRR (ratio of the durations of the forward stroke and the return stroke)

As, $$V_C = \frac{sxN_s}{1000}\left(1+\frac{1}{QRR}\right) m/\min \tag{4.5.1}$$

To reduce idle time, return stroke is made faster and hence QRR > 1.0 (4.5.2)

Since $$QRR = \frac{2L+s}{2L-s} \tag{4.5.3}$$

where, L = length (fixed) of the oscillating lever

and s = stroke length

The benefit of quick return decreases when S becomes less.

The changes in length of stroke and position of the stroke required for different machining are accomplished respectively by

- ⊗ Adjusting the crank length by rotating the bevel gear mounted coaxially with the bull gear
- ⊗ Shifting the nut by rotating the leadscrew as shown in Fig. 4.4.5.

The value of N_s is varied by operating the speed gear box.

The main (horizontal) feed motion of the work table is provided at different rate by using the ratchet – paul systen as shown in Fig. 4.4.5. The vertical feed or change in height of the tool tip from the bed can be obtained either by lowering the tool or raising the bed by rotating the respective wheel as indicated in Fig. 4.4.5.

- **Planing machine**

The simple kinematic system of the planing machine enables transmission and transformation of rotation of the main motor into reciprocating motion of the large work table and the slow transverse feed motions (horizontal and vertical) of the tools. The reciprocation of the table, which imparts cutting motion to the job, is attained by rack-pinion mechanism. The rack is fitted with the table at its bottom surface and the pinion is fitted on the output shaft of the speed gear box which not only enables change in the number of stroke per minute but also quick return of the table.

The blocks holding the cutting tools are moved horizontally along the rail by screw-nut system and the rail is again moved up and down by another screw- nut pair as indicated in Fig. 4.4.3.

- **Slotting machine**

The schematic view of slotting machine is typically shown in Fig. 4.4.6

The vertical slide holding the cutting tool is reciprocated by a crank and connecting rod mechanism, so here quick return effect is absent. The job, to be machined, is mounted directly or in a vice on the work table. Like shaping machine, in slotting machine also the fast cutting motion is imparted to the tool and the feed motions to the job. In slotting machine, in addition to the longitudinal and cross feeds, a rotary feed motion is also provided in the work table. The intermittent rotation of the feed rod is derived from the driving shaft with the help of a four bar linkage as shown in the kinematic diagram.

It is also indicated in Fig. 4.4.6 how the intermittent rotation of the feed rod is transmitted to the leadsrews for the two linear feeds and to the worm – worm wheel for rotating the work table. The working speed, i.e., number of strokes per minute, N_s may be changed, if necessary by changing the belt-pulley ratio or using an additional "speed gear box", whereas, the feed values are changed mainly by changing the amount of angular rotation of the feed rod per stroke of the tool. This is done by adjusting the amount of angle of oscillation of the paul as shown in Fig. 4.4.6. The directions of the feeds are reversed simply by rotating the tapered paul by 180° as done in shaping machines.

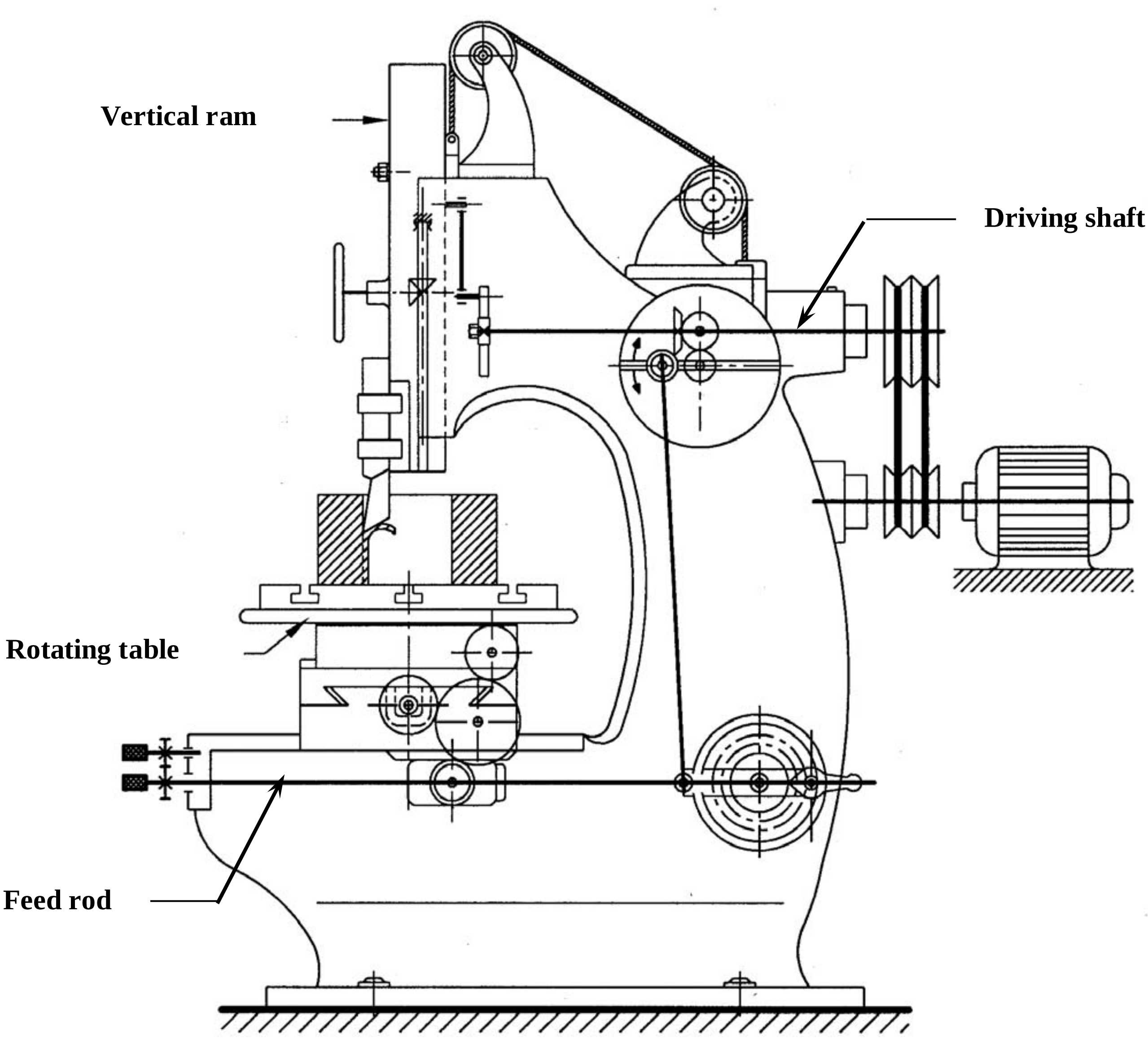


Fig. 4.4.6 *Kinematic system of a slotting machine.*

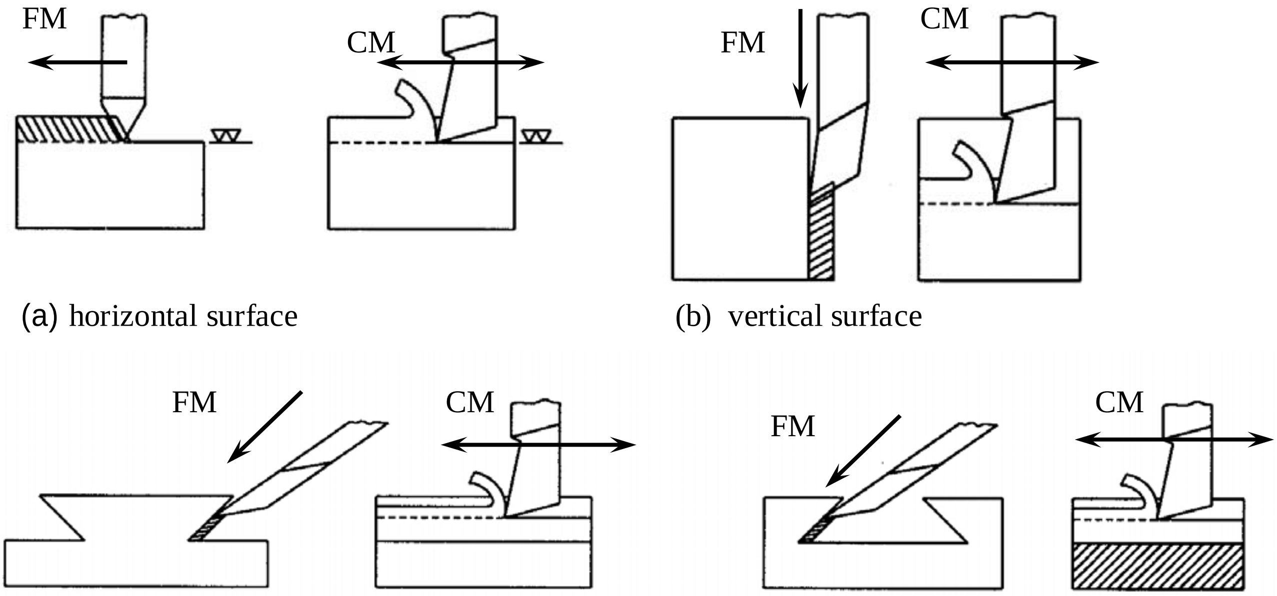
(iii) Various applications of

- Shaping machine
- Planing machines
- Slotting machines

- **Shaping machines**

It is already mentioned that shaping machines are neither productive nor versatile. However, its limited applications include :

⊗ Machining flat surfaces in different planes. Fig. 4.4.7 shows how flat surfaces are produced in shaping machines by single point cutting tools in (a) horizontal, (b) vertical and (c) inclined planes.



(a) horizontal surface (b) vertical surface

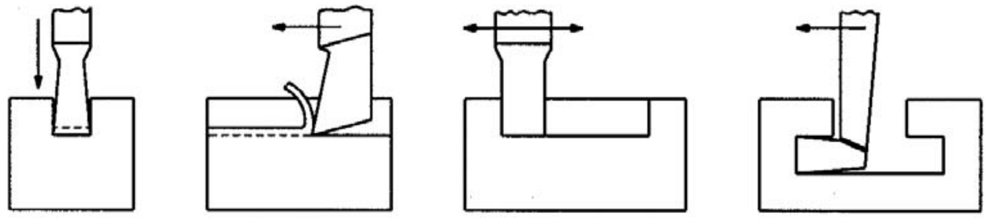
(c) inclined surfaces (dovetail slides and guides)

Fig. 4.4.7 *Machining of flat surfaces in shaping machines*

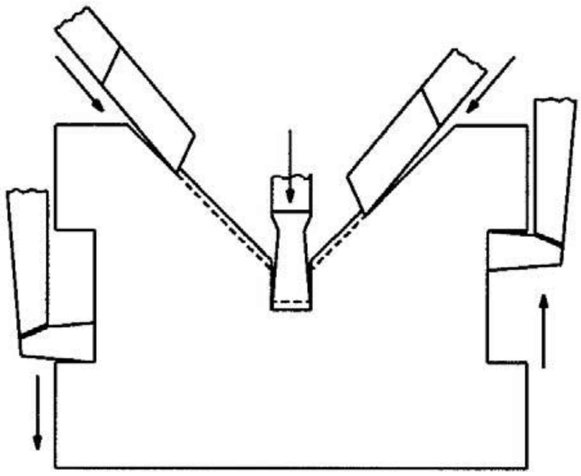
⊗ Making features like slots, steps etc. which are also bounded by flat surfaces. Fig. 4.4.8 visualises the methods of machining (a) slot, (b) pocket (c) T-slot and (d) Vee-block in shaping machine by single point tools.

⊗ Forming grooves bounded by short width curved surfaces by using single point but form tools. Fig. 4.4.9 typically shows how (a) oil grooves and (b) straight tooth of spur gears can be made in shaping machine

⊗ Some other machining applications of shaping machines are cutting external keyway and splines, smooth slitting or parting, cutting teeth of rack for repair etc. using simple or form type single point cutting tools. Some unusual work can also be done, if needed, by developing and using special attachments.

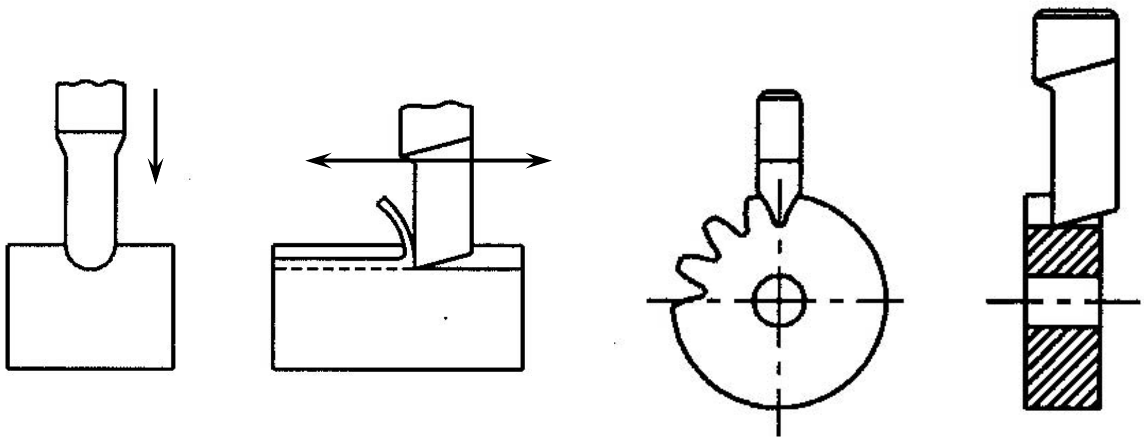


(a) slotting (b) pocketing (c) T-slot cutting



(d) Vee-block

Fig. 4.4.8 *Machining (a) slot, (b) pocket (c) T-slot and (d) Vee block in shaping machine*



(a) grooving (b) straight tooth cutting for spur gears

Fig. 4.4.9 *Making grooves and gear teeth cutting in shaping machine by form tools*.

However, due to very low productivity, less versatility and poor process capability, shaping machines are not employed for lot and even batch production. Such low cost primitive machine tools may be reasonably used only for little or few machining work on one or few pieces required for repair and maintenance work in small machine shops.

- **Planing machines**

The basic principles of machining by relative tool-work motions are quite similar in shaping machine and planing machine. The fast straight path cutting motion is provided by reciprocation of the tool or job and the slow, intermittent transverse feed motions are imparted to the job or tool. In respect of machining applications also these two machine tools are very close. All the operations done in shaping machine can be done in planing machine. But large size and stroke length and higher rigidity enable the planing machines do more heavy duty work on large jobs and their long surfaces. Simultaneous use of number of tools further enhances the production capacity of planing machines.
The usual and possible machining applications of planing machines are

⊗ The common machining work shown in Fig. 4.4.7, Fig. 4.4.8 and Fig. 4.4.9 which are also done in shaping machines

⊗ Machining the salient features like the principal surfaces and guideways of beds and tables of various machines like lathes, milling machines, grinding machines and planing machines itself, broaching machines etc. are the common applications of planing machine as indicated in Fig. 4.4.10 where the several parallel surfaces of typical machine bed and guideway are surfaced by a number of single point HSS or carbide tools. Besides that the long parallel T-slots, Vee and inverted Vee type guideways are also machined in planing machines.

⊗ Besides the general machining work, some other critical work like helical grooving on large rods, long and wide 2-D curved surfaces, repetitive oil grooves etc. can also be made, if needed, by using suitable special attachments.

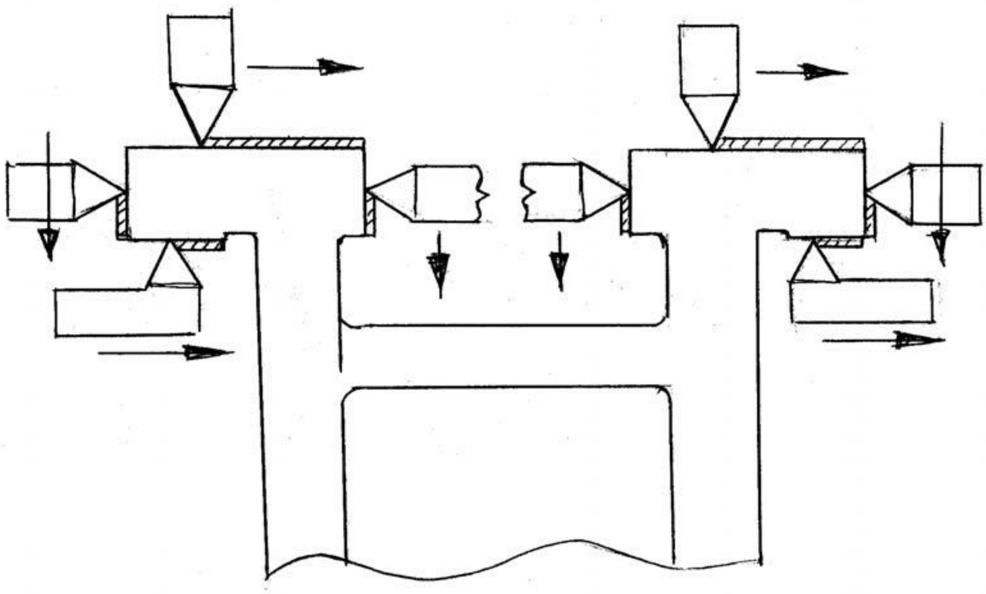


Fig. 4.4.10 *Machining of a machine bed in planing machine*

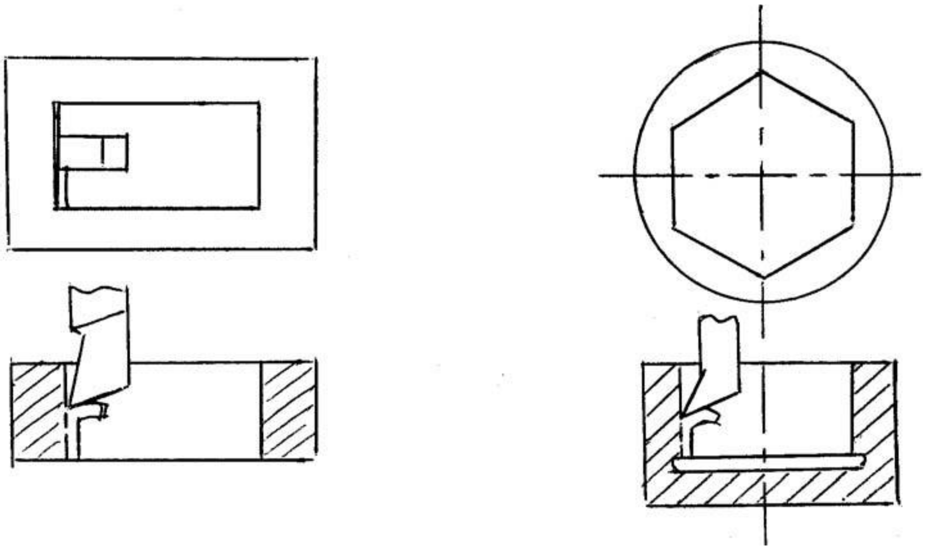
- **Slotting machine**

Slotting machines are very similar to shaping machines in respect of machining principle, tool-work motions and general applications. However, relative to shaping machine, slotting machines are characterised by :

⊗ Vertical tool reciprocation with down stroke acting
⊗ Longer stroke length
⊗ Less strong and rigid
⊗ An additional rotary feed motion of the work table
⊗ Used mostly for machining internal surfaces.

The usual and possible machining applications of slotting machines are :

- Internal flat surfaces
- Enlargement and / or finishing non-circular holes bounded by a number of flat surfaces as shown in Fig. 4.4.11 (a)
- Blind geometrical holes like hexagonal socket as shown in Fig. 4.4.11 (b)
- Internal grooves and slots of rectangular and curved sections.
- Internal keyways and splines, straight tooth of internal spur gears, internal curved surface of circular section, internal oil grooves etc. which are not possible in shaping machines.



(a) through rectangular hole (b) hexagonal socket

Fig. 4.4.11 *Typical machining application of slotting machine.*

However, it has to be borne in mind that productivity and process capability of slotting machines are very poor and hence used mostly for piece production required by maintenance and repair in small industries. Scope of use of slotting machine for production has been further reduced by more and regular use of broaching machines.

Exercise

Identify the correct answer from the given four options.

1. Reciprocation of the cutting tool in shaping machines is accomplished by
    a. Rack pinion mechanism
    b. Crank and connecting rod mechanism
    c. Cam and cam follower mechanism
    d. Oscillating lever mechanism
2. Internal keyway in gears can be cut in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. None of the above
3. The job reciprocates in
    a. Shaping machine
    b. Planing machine
    c. slotting machine
    d. All of the above
4. The T-slots in the table of planing machines are cut in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. None of the above
5. Flat surface can be produced in
    a. Shaping machine only
    b. Planing machine only
    c. Slotting machine only
    d. All of the above
6. Large number of cutting tools can be simultaneously used in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. None of the above

7. Heavy cuts can be given during machining in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. None of the above
8. Slotting machines are used to cut internal gear teeth for
    a. Batch production
    b. Lot production
    c. Mass production
    d. None of the above
9. The work-table can rotate in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. None of the above

10. Length of the stroke can be varied in
    a. Shaping machine
    b. Planing machine
    c. Slotting machine
    d. All of the above

Answers

Q.No	Answers
1	d
2	c
3	b
4	b
5	d
6	b
7	b
8	a
9	c
10	b

Drilling Machine

The drilling machine is defined as a machine which is used to make a circular hole, a tool used to drill the holes of different size and other related operations using a drill bit.

The drilling machine is one of the most important machines in a workshop. As regards its importance it is second only to the lathe machines. Holes were drilled by the Egyptians in 1200 B.C. about 3000 years ago by bow drills. The bow drill is the mother of present-day metal cutting drilling machine.

Drilling Machine

In drilling, machine holes may be drilled quickly and at a low cost. The hole is generated by the rotating edge of a cutting tool known as the drill which applies a large force on the work clamped on the table. As the machine uses vertical pressure to originate a hole it is loosely called a "drill press".

Parts of Drilling Machine

Following are the main parts of drilling machines:

1. Base
2. Column
3. Table
4. Radial Arm
5. Drill head
6. Spindle speed and Feed mechanism.

Read also: ***Milling Machine: Main Parts and its Working Principle***

Base

The base is that part of the machine on which the vertical column is mounted. The base is made of casting. A base supports the column and worktable with other attachments. The top of the base is round column section type upright drilling machined and has T-slots on it so that large workpieces and work holding devices may be set up and bolted to it. The base of the machine may be mounted on a bench or on the floor.

Column

The Column is the verticle member of the machine which supports the table and the head containing all the driving mechanism. It is a cylindrical casting mounted vertically at one end of the base and supports the radial arm, which slides up and down.

An electric motor at the top of the column helps in the vertical adjustment of the arm by rotating a screw passing through a nut attached to the arm.

Table

The table is mounted on the column and is provided with T-slots for clamping the work directly on its face. A table is round or rectangular in shape.

Radial Arm

It is mounted on the column and extends horizontally over the base. It has guide ways on which drill head slides. The radial arm moves around the column.

Drill head

It is mounted on the redial arm and drives the drill spindle. In some of the drill machines, the drill head may be adjusted up or down for accommodating different heights of the work in addition to the table adjustment.

It encloses all the mechanism for driving the drill at a different speed and feeds. In lighter machines, the driving motor is mounted at the rear end of the head counterbalancing the weight of the drill spindle.

Spindle speed and feed mechanism

The motor at the top of the drill head drives the horizontal spindle and the motion is transmitted to the drill head through a group of bevel gears. With another group of gears, different spindle speed and feed are obtained.

The main advantage of this type of drilling machine is that holes of variable sizes at any point and at any angles can be drilled on the large-sized work piece without moving the work piece.

*Read also: **Shaper Machine and The 4 Major Types of Shaper Machines***

Types of Drilling Machine

Following are the 8 different **types of drilling machine.**

1. Portable drilling machine
2. Sensitive drilling machine
    a) Bench mounting sensitive drilling machine
    b) Floor column upright drilling machine
3. Upright drilling machine
    a) Round column upright drilling machine
    b) Box column upright drilling machine
4. Radial drilling machine
    a) Plain drilling machine
    b) Universal drilling machine
    c) Semi-universal drilling machine
5. Gang drilling machine
6. Multiple spindle machine
7. Automatic drilling machine
8. Deep hole drilling machine
    a) Vertical deep hole drilling machine
    b) Horizontal deep hole drilling machine

1. Portable Drilling Machine

This types of drilling machines are commonly used in all the workshop. Used to drill small sized holes. It is operated by holding in a hand. The workpiece where the hole is to be drilled is held in a vice.

2. Sensitive Drilling Machine

These types of drilling machine used to drill small holes at high speeds in lighter jobs or workpieces. The machine may be mounted on the bench or floor & the drilling work is started with the drill fed into the workpiece by purely hand control.

Read also: ***15 Different Types of Milling Machines [Full Guide]***

Since the operator senses the cutting action at any instant it is called as the sensitive drilling machine. These machines are capable of drilling small holes of diameter as small as 0.35 mm to 15 mm. These machines run at a higher speed as high as 2000 rpm.

3. Upright Drilling Machine

It is larger in size and stronger than sensitive drilling machine. It is used for drilling medium and large-sized holes. Based on the type of column used it is classified as a round column and box column upright drilling machines.

4. Radial Drilling Machine

The schematic diagram of the radial drilling machine is shown in the figure. It consists of the base, column radial arm, drill head, spindle speed and feed mechanism.

Read also: 22 Different Types of Lathe Machine Operations

5. Gang Drilling Machine

This machine consists of the number of drill heads placed side by side so that more than one hole of same or different sizes can be drilled at a time on the same job or on different jobs.

The space between drill spindles is varied to suit the gap between the holes. This type of machine tool is used to drill a large number of holes in the same job at a faster rate.

The main advantage of this type of machine tool is that the series of operation can be performed with different spindle. mounted with different tool bits on the same work piece by moving it from one position to another position.

Read also: **[Lathe Machine: Parts, Types, Operations, Accessories, Attachments]**

6. Multi Spindle Drilling Machine

This machine tool is similar to a gang drilling machine in construction. It is used to drill the number of hole in the same workpiece simultaneously and to reproduce the same work in a number of similar jobs.

7. Automatic Drilling Machine

This type of machines can perform a series of machining operations at successive units and transfer the work from one unit to the other automatically.

Automatic Drilling Machine

Once the work is loaded at the first machine, the work will move from one machine to the other where different operations can be performed and the finished work comes out from the last unit without any manual handling.

This type of machine is intended purely for production purposes and may be used for milling, honing and similar operations in addition to drilling and tapping.

8. Deep Hole Drilling Machine

This may be the either horizontal or vertical type of machine. In this drilling machine, the part to be drilled is rotated and the drill bit that makes the hole is kept stationary. Deep hole drilling is done in components like rifle barrels, crankshafts, long shafts etc.

Read also: ***[Slotter Machine: Types, Parts and Operations [Complete Guide]]***

Drilling Machine Tools

Drill: A drill is a fluted cutting tool used to originated or enlarge a hole in a solid material. Drills are manufactured in a wide variety of types and sizes.

Following are the different types of tools used in drilling machine:

1. Flat or spade drill tool
2. Straight fluted drill tool
3. Two-lip twist drill tool
   a) Parallel shank (short series or ‘’ jobbers’’ twist drill)
   b) A Parallel shank (stub series) twist drill
   c) Parallel shank (long series) twist drill
   d) A Parallel shank twist drill
2. Taper shank core drill (Three or four fluted)
3. Oil tube drill
4. Centre drill

1. Flat or Spade Drill

A flat drill is sometimes used when the same sized twist drill is not available. It is usually made from a piece of round tool steel which is forged to shape and ground to size, then hardened and tempered.

The cutting angle varies from 90 to 120 and the relief or clearance at the cutting edge is 3to 8. The disadvantage of this type of drill is that each time the drill id ground the diameter is reduced.

Further, it cannot be relied upon to drill a true straight hole, since the point of the drill has a tendency to run out of a centre.

Another difficulty of using this type of drill is that the chips do not come out from the hole automatically, but tends to pack more or less tightly, if deep holes are to be drilled.

2. Straight Fluted Drill:

A straight-fluted drill has grooves or flutes running parallel to the drill axis. A straight-fluted drill may be considered as a cutting tool having zero rakes.

This type of drill is inconvenient in standard practice as the chips do not come out from the hole automatically. It is mainly used in drilling brass, copper or other softer materials.

In drilling brass, the twist drill tends to advance faster than the rated feed and the drill digs into the metal. No such difficulty occurs in the use of a straight fluted drill. When drilling sheet metal, the straight fluted drill does not tend to lift the sheet as does the twist drill.

3. Twist Drill

This is the most common type of drill used today is the twist drill. It was originally manufactured by twisting a flat piece of tool steel longitudinally for several revolutions, then grinding the diameter and the point.

The present-day twist drills are made by machining two spiral flutes or grooves that run lengthwise around the body of the drill.

The twist drill is an end cutting tool. Different types of twist drills are classified by Indian standard Institution according to the type of the shank, length of the flute and overall length of the drill.

Parallel Shank (short series or "jobbers" twist drill)

The drill has two helical flutes with a parallel shank of approximately the same diameter as the cutting end. The diameter of the drill ranges from 02 to 16 mm increasing by 02 to 03 mm in lower series to 025 mm in higher series. Fig 5.36 illustrates the drill.

Parallel Shank (stub series) twist drill

The drill is a shortened form of the parallel shank twist drill, the shortening being on the flute length. The diameter of the drill ranges from 05 to 40 mm increasing by 03 mm in lower series to 025 to 05 mm in higher series. Fig. 5.37 illustrates the drill.

Read also: ***Difference Between Capstan and Turret Lathes***

Parallel Shank (long series) Twist Drill

The drill has two helical flutes with a parallel shank of approximately the shank diameter as the cutting end, which however does not exceed the diameter at the drill point.

The overall length of the drill is the same as that of a taper shank twist drill of the corresponding diameter. The diameter varies from 1-5 to 26mm increasing by 0-3mm in lower series to 0-25mm in higher series.

Taper Shank Twist Drill

The drills have two helical flutes with a tapered shank for holding and driving the drill. The shank for these drills conforms to Morse tapers.

The diameter ranges from 3 to 100mm. The diameter increases by 0-3mm in lowest series having Morse taper shank No. 1, by 0-25mm in lowest series shank number 2 and 3, by 0-5mm in Morse taper shank No. 4, and by 1mm in Morse taper shank number 5 and 6.

The use of Morse taper shank below 6mm size is not preferred. A drill gauge enables any drill to be readily selected by gauge.

4. Taper Shank Core Drill (three or four fluted)

These drills are intended for enlarging cored, punched or drilled holes. These drills cannot originate a hole in a solid material because the cutting edges do not extend to the centre of the drill.

The metal is removed by a chamfered edge at the end of each flute. Cored drills produce better- finished holes than those cut by ordinary two fluted drills.

The cutting action of a core drill is similar to that of a rose reamer and it is often used as a roughing reamer. In some cases, a two fluted twist drill is chosen to originate a hole half the required size and the rest is finished by a three or four fluted drills.

5. Oil Tube Drill

The oil tube drills are used for drilling deep holes. Oil tubes run lengthwise spirally through the body to carry oil directly to the cutting edges.

Cutting fluid or compressed air is forced through the hoes to the cutting point of the drill to remove the chips, cool the cutting edge and lubricate the machined surface.

6. Centre Drill

The centre drills are a straight shank, two fluted twist drills used when centre holes are drilled on the ends of a shaft. They are made in finer sizes.

Read also: **14 Different Types of Lathe Cutting Tools**

Drilling Machine Operations

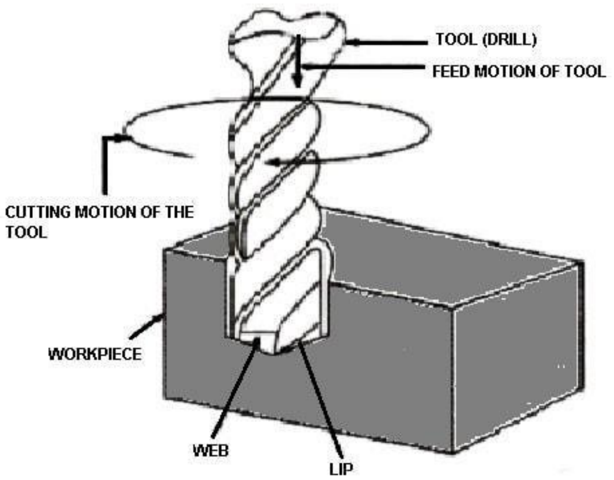
Following are the different types of operations performed on the drilling machine:

1. Drilling operation
2. Reaming operation
3. Boring operation
4. Counterboring operation
5. Countersinking operation
6. Spot facing operation
7. Tapping operation
8. Lapping operation
9. Grinding operation
10. Trepanning operation

1. Drilling

Drilling is the operation of producing a cylindrical hole by removing metal from the rotating edge of a cutting tool called the drill.

The drilling is one of the simplest methods of producing a hole. Before drilling the centre of the hole is located on the workpiece by drawing two lines at right angles to each other and then a centre punch is used to produce an indentation at the centre.



DRILLING OPEERATION

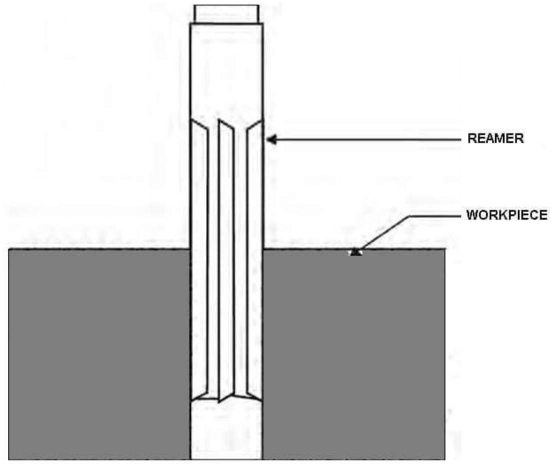
The drill point is pressed at this centre point to produce the required hole. Drilling does not produce an accurate hole in a workpiece and the hole location is not perfect.

The internal surface of the hole so generated by drilling becomes rough and the hole is always slightly oversize than the drill used due to the vibration of the spindle and the drill. A 12mm drill may produce a hole as much as 0-125mm oversize and a 22mm drill may produce one as much as 0-5mm oversize.

Read also: ***16 Different Types of Milling Cutters [Complete Guide]***

2. Reaming

Reaming is an accurate way of sizing and finishing a hole which has been previously drilled. In order to finish a hole and to bring it to the accurate size, the hole is drilled slightly undersize.

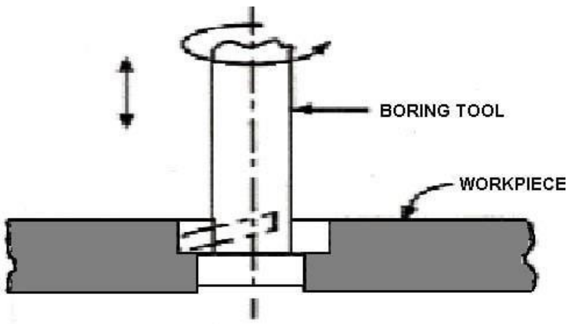


REAMING OPERATION

The speed of the spindle is made half that of drilling and automatic feed may be employed. The tool used for reaming is known as reamer which has multiple cutting edges.

Reamer cannot originate a hole. It simply follows the path which has been previously drilled and removes a very small amount of metal. For this reason, a reamer cannot correct a hole location. The material removed by this process is around 0-375mm and for accurate work, this should not exceed 0-125mm.

3. Boring



BORING OPERATION

Boring is performed in a drilling machine for reasons stated below:

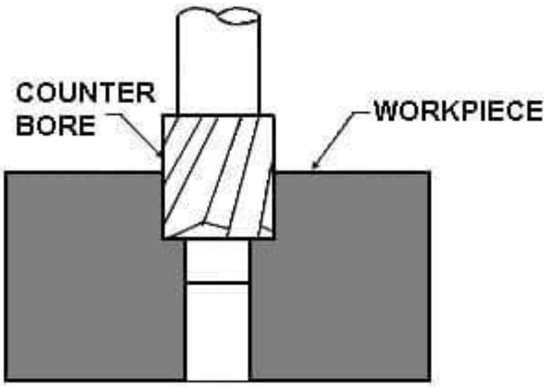
- To enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where the suitable sized drill is not available or where the hole diameter is so large that it cannot be ordinarily drilled.
- Used to finish a hole accurately and to bring it to the required size.
- To machine the internal surface of a hole already produced in casting.
- Used to correct out of roundness of the hole.

- To correct the location of the hole as the boring tool follows an independent path with respect to the hole.

The cutter is held in a boring bar which has a tapered shank to fit into the spindle socket. For perfect finishing a hole, the job is drilled slightly undersize. In precision machines, the accuracy is as high as
+0.00125mm. It is a slow process than reaming and requires several passes of the toll.

4. Counterboring

Counterboring is the operation of enlarging the end of a hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins.



COUNTERBORING OPERATION

A tool used for counterboring is called a counterbore. The counterbores are made with a straight or tapered shank to fit in the drill spindle. The cutting edges may have straight or spiral teeth.

The tool is guided by a pilot which extends beyond the end of the cutting edges. The pilot fits into the small-diameter hole running clearance and maintains the alignment of the tool.

These pilots may be interchanged for enlarging different sizes of holes. Counterboring can give an accuracy of about +0.005mm. The cutting speed for counterboring is 25% less than that of drilling operations.

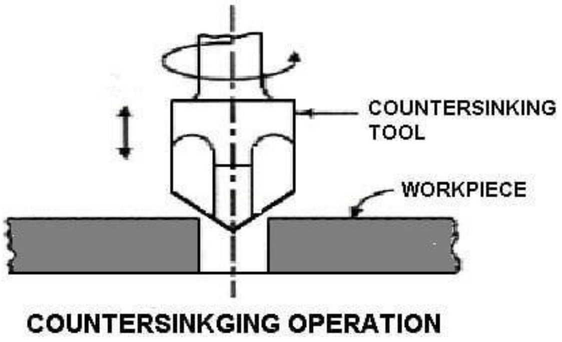
5. Countersinking

Countersinking is the operation of making a cone-shaped enlargement of the end of a hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole.

The tool used for countersinking is called a countersink. Standard countersinks have 60, 82 or 90 inclined angle and the cutting edges of the tool are formed at the conical surface. The cutting speed in countersinking is 25% less than that of drilling.

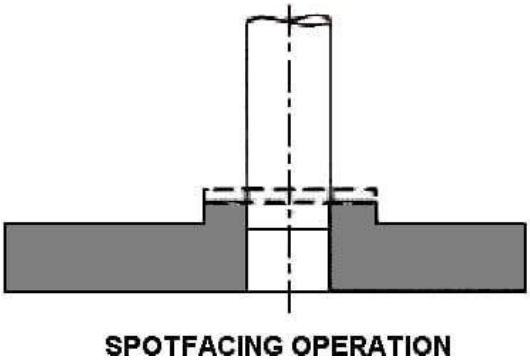
Read also: ***The Complete List of Milling Machine Operations***

Read also: **Metal Saw Machine and Types of Sawing Machine**



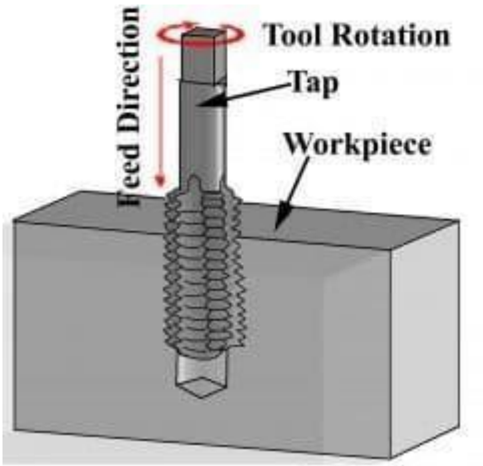
6. Spot facing

Spot facing is the operation of smoothing and squaring the surface around a hole for the seat for a nut or the head of a screw. A counterbore or a special spot facing tool may be employed for this purpose.



7. Tapping

It is the operation of cutting internal threads by means of a cutting tool called a tap. Tapping in a drilling machine may be performed by hand or by machine.



A tap may be considered as a bolt with accurate threads cut on it. The threads act as cutting edges which are hardened and ground. When the tap is screwed into the hole it removes metal and cuts internal threads which will fit into external threads of the same size.

8. Lapping

Lapping is the operation of sizing and finishing a small diameter hole already hardened by removing a very small amount of material by using a lap. There are many kinds of lapping tools.

The copper head laps are commonly used. The lap fits in the hole and is moved up and down while it revolves.

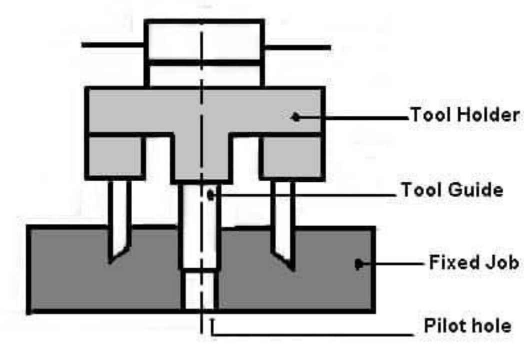
9. Grinding

Grinding operation may be performed in a drilling machine to finish a hardened hole. The grinding wheel is made to revolve with the spindle and is fed up and down.

A suitable grinding wheel may be selected for surface grinding operation. Grinding can also be done correctly out of roundness of the hole. The accuracy in grinding operation is quite high about
+0.0025mm.

10. Trepanning

Trepanning is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool.



TREPANNING OPERATION

This operation is performed for producing large holes. Fewer chips are removed and much of the material is saved while the hole is produced.

The tool may be operated at higher speeds as the vibration in diameter of the tool is limited by the narrow cutting edge. The tool resembles a hollow tube having cutting edges at one end and a solid shank at the other to fit into the drill spindle. This is one of the efficient methods of producing a hole.

That's it, Thanks for reading. If you find this article helpful share this with your friends. Have any questions about drilling machine leave a comment. Join our community by liking our facebook page. Subscribe our newsletter to get notification of our new posts.

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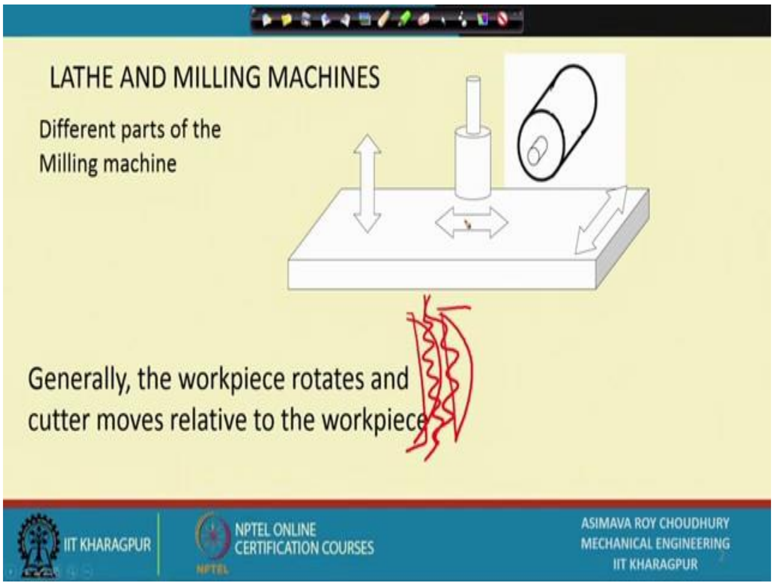
MODULE-IV

MILLING AND GRINDING

Welcome viewers to the sixteenth lecture of the open online course Metal Cutting and Machine Tools. So, in this lecture we will be learning about milling machines, their kinetic structure and what kind of operations, specialized operations that can be done on the milling machine. So, let us start right away with the first slide metal cutting and machine tools; milling machines.



So, the different parts of the milling machine; the first thing that we get conversion with the milling machine is the table. This is the place where the operator directly interacts with the machine, the table can move up and down vertically up and down and assuming the table to be horizontal; it can move sideways, this is the longitudinal motion and it can also move transverse, cross towards the operator or away from the operator. This is the typical configuration of a tool whose axis is axis of rotation is vertical and in that case the machine gets the name vertical milling machine.

In this case this axis I mean axis of this tool is horizontal and if this sort of a tool is used the machine gets the name horizontal milling machine. And what is the basic structure of the machine and of course, generally the generally the work piece sorry this is pertaining to please for the time being please do not consider this one no ok. So, let us move on to you know let us let us try to visualize them what is the milling machine all about.

So, the milling machine first of all has a table; this is the table and the machine looks just like someone who is resting the table on his leg. And you know leaning on the machine and doing some very important work; this is the milling machine.

So, from that this structure on the machine will be called knee and this columnar structure that his torso is creating; this is the column and we get the name column and knee type milling machine. What is this head? This is jelly you know this part is concerned with the cutter; cutter rotation, cutter inclination, etcetera, etcetera. And this is the table which can be put as we discussed up or down, it can be moved longitudinally, it can also move cross.

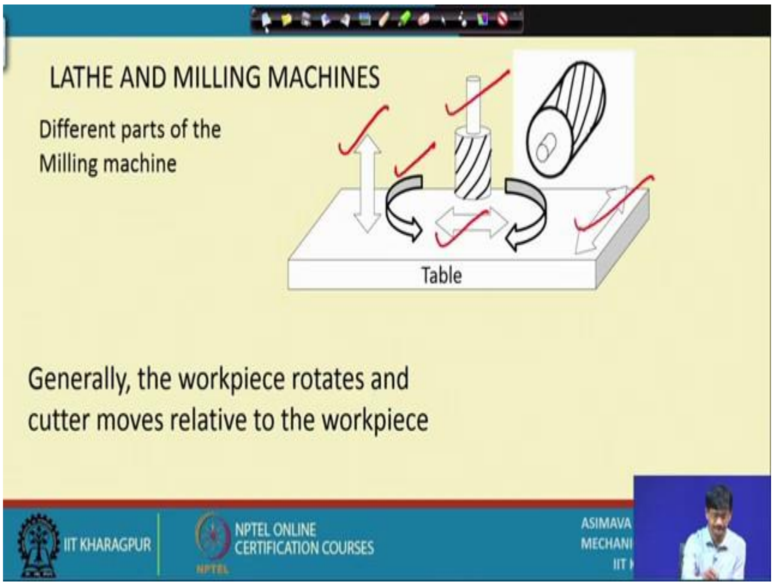
So, let us now look at you know vertical milling machine; we have already understood that the cutter is vertical. The horizontal milling machine also we understood axis of rotation of the cutter is vertical; I mean horizontal. So, apart from that the column and the knee ok; the column gives the you know structural support to the all the cutters and its required you know rotational motion etcetera; all those things the column is at the back giving support to the main machine. And although kinematic connections are through the column and the knee supports the table.

Knee is basically if we draw it here itself knee is comprising of a vertical screw. This vertical screw when it is rotated the table as you know as nut moves up or down. So, this forms the basic support if this be so, under the huge load of the whole machine table; together with the work piece weight which can be to the order of you know to the tune of say 200 kgs, 250 kgs like that.

So, the knee might buckle; so, why go for such a structure? In fact, for you know production type machines generally they go for a fixed bed type machine where the table does not have such a structure and the table does not go up or down. The cutter assembly moves down or moves up so that this question of buckling does not take place; this forms a weak point of the machine.

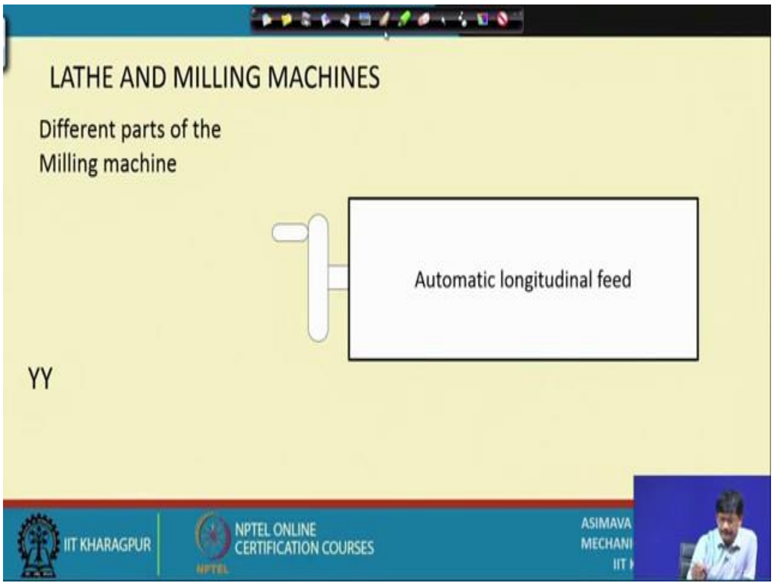
So, this is generally restricted to those particular you know machines which are of low duty medium duty and which are you know operator controlled. If it is column and knee type structure, the front structure is you know front part is open for the operator to interact. It is easier for the operator to place something on the table to unclamp, clamp something on the table etcetera. So, for that kind of machines column and knee type structure is good, but for production machines where heavy cuts have to be taken; in that generally fixed bed type machines are preferred where there is no provision of the table to move up up and down, it is you know supported on a very robust structure which is not columnar. So, it does not have any chance of buckling.

So, with this let us you know move on to the next one. So, these are the teeth of the cutter, these are helical you know slab milling cutters shown.

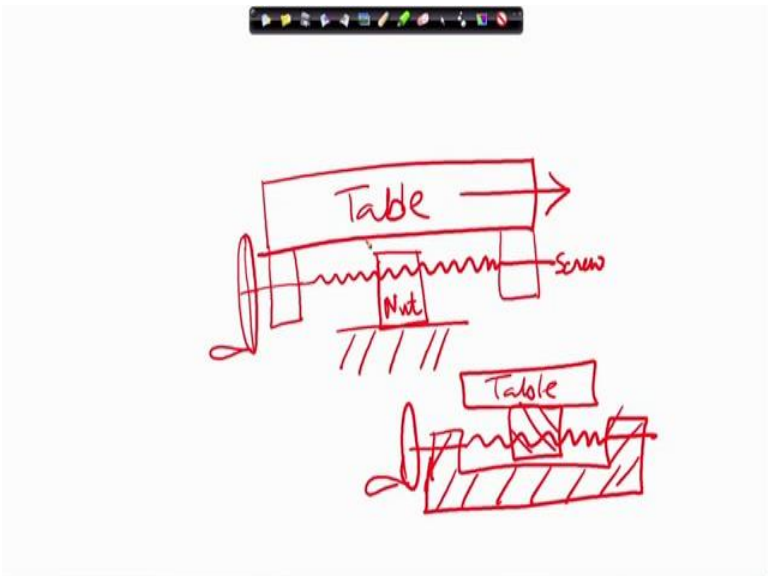


The table; apart from these three motions may also rotate about a vertical axis. Rotate means for setting; setting up operations, so if it is capable of rotation about a vertical axis in that case it is called a universal milling machine. So, we might say say column and knee type a vertical column and knee type universal milling machine.

So, what does it mean? It means vertical column and knee type gives gives the structure of the basic machine and universal milling machine. These things are you know already there because we have named a column and knee type milling machine, where these motions will be given to the table. So, vertical column and knee type universal milling machine; so, this way we can easily you know specify milling machines.



So, let us see how automatic longitudinal feed is obtained on the table; what does the table do? The table rotates this way; see the handle is also rotating automatically. So, by this very thing we understand that if the table is rotated a moved automatically, the handle also rotates. How is this made possible? Let us have a quick look.

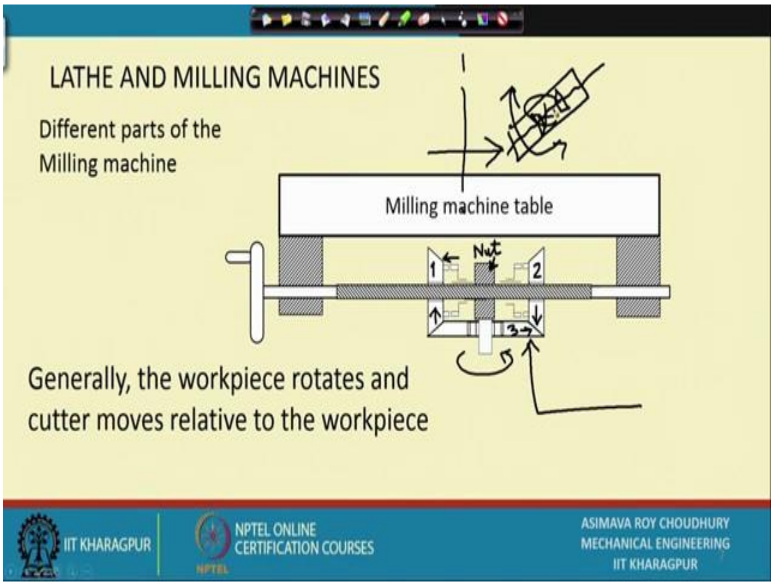


It can be made possible if this is the table you know something is sticking out here and this is our handle and this is a nut; nut is fixed see that is it. The advantage of this is that mind you here there is clearance these are almost touching they should not.

So, nut is fixed screw rotates; so, the whole thing together with the handle, with the table etcetera; they start moving from one position to another due to the by virtue of this rotation; table moves these you know support, bearings move, this screw moves together nut remains stationary. Otherwise in other configurations, they would have been a distance created between the handle and the table that is if we fix it; this way say.

This is the screw and this is the table with a nut, then you would have had problems you will find that this table is moving and the distance getting created between the handle and the table; that is not so, in at least in the machines that we come across; this is the thing ok. So, once we understand how the table is configured.

Let us see how the universal milling machine is working; how it operates? And mind you this is a setting movement during machining generally the universal milling machine table does not rotate about the vertical axis. So, this is the rotation that we are talking about; looking from the top you can set it to any angle that you want ok.



This is a possible configuration of what is going on inside; you know first of all let us look at that nut that we were talking about; this is the nut just a moment this is the nut this is the nut ok. And what is the nut doing? The screw is passing through it and therefore, the nut beings being held steady somewhere, it is making the table move.

So, the table will be suffering motion like this; what are these things on the sides? These are bevel gears. So, there is a basic you know a cradle bevel gear or a crown bevel gear here. And connected to that there are two bevel gears which if they rotate, they are going to move all around ok. They are going to move on these circular rails it is it is just like merry ground they will go around in a sort of merry ground motion ok.

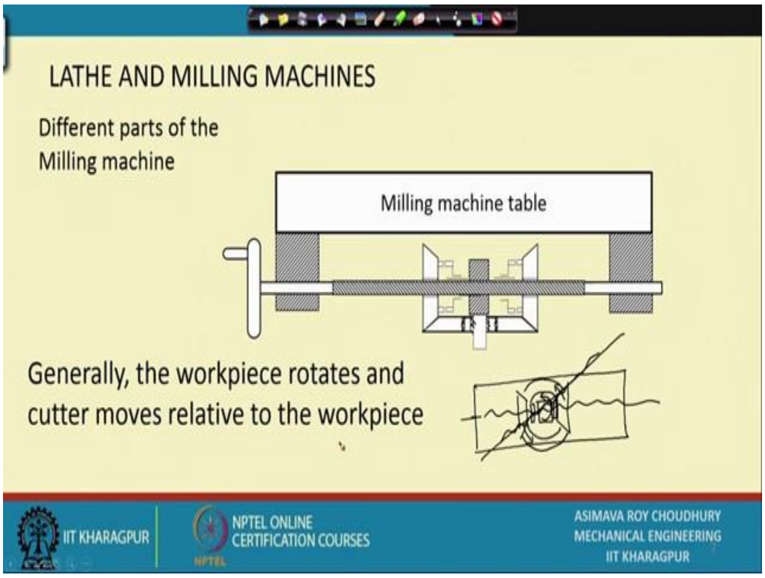
So, if I rotate this handle; this screw moves through and the table moves. Then what are these two things doing? These are called clutches what they do is; if they if they move this way they connect up with this particular bevel gear 1; let us name it 1 and let us name it 2 and this one 2. So, if 3 is rotating this way ok; that means, it is moving this way; so, this bevel gear moves this way and that bevel gear moves that way.

So, you can clearly see rotations directions of rotation of 1 and 2; they are opposite. So, if this clutch; clutches on to 1, it transfers motion from one to the lead screw and the lead screw rotates. So, basically I am bringing in power from the motor, I am making three rotates somehow and once 3 is rotating 1 and 2 rotate, but they are not intimately connected with the lead screw. Lead screw gets its connection by you know; either by pushing this clutch this way so, that power flows from 1 to the lead screw or if it is shifted this way power flows from 2 to the lead screw; that way you can derive power automatically and make the screw rotate.

In addition to that you have the ability to choose the direction of rotation. So, with the help of this one this is called the clutch ok; so bi directional clutch. So, I am able to choose the direction of rotation; I am able to derive or power from the you know whatever primary prime mover I have that is a motor

So, I am deriving power from the motor right up to this lead screw, I am making it rotate I am rotating it in the direction that I want. And that way the screw is rotating, if the screw rotates the nut makes the screw the table move; this way. But if I already you know rotate the milling machine table about a vertical axis will not the screw run out of contact with these? No, these will simply as we notice before these will simply shift position out of the plane of the paper, but they will still remain in contact with the prime moving bevel gear number three because they are going round, they are not coming out laterally outside the plane of the paper; they are going round on this particular bevel gear.

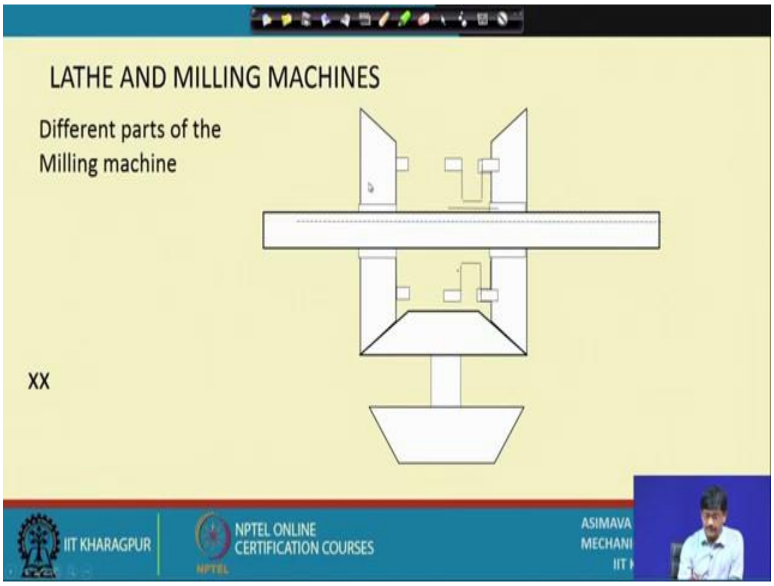
So, always they remain in contact simply as we saw before; the table from looking from the top is going to just shift this way. The screw is going to be this way, the bevel gear is going to be these are going to be the bevel gears ok. And they are going to go round sorry let me rub this one and try to draw a clearer version it is something like this.



Looking from the top we have looking from the top we have this to be the table; this to be the screw, these to be the bevel gears and they are rotating on top of another bevel gear and inside there is the nut and on this side there is the clutch. So, even if the this thing changes; this moves this way, this moves that way, the screw comes here; everything still remains in contact, so this way we are taking care of it.

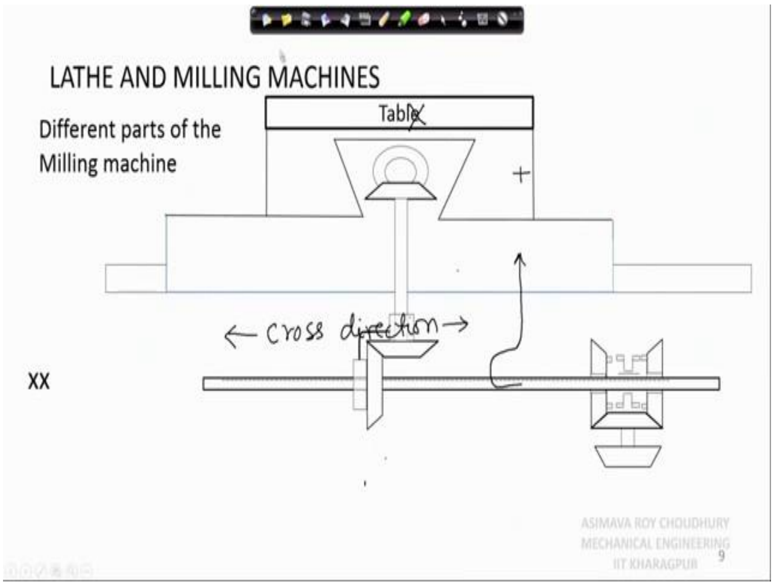
But what happens to the nut? The nut we said is stationary. So, the nut is you know nut rotates about its axis and it is connected to this bevel gear by means of this ball bearing. So, with the screw the nut has to rotate from its initial angular position; nut rotates this nut rotates. So, this way the whole thing can be taken care of.

I am having rotation of table, I am having automatic motion coming to the screw, I am having direction also selected. However, this sort of you know complex mechanism is not always implemented in one step itself, this clutch is taken out and it is it is made use of in a different shaft. Because this sort of y directional clutch; here it has to be in two parts, generally it is in a single part let us quickly have a look at it.



By the way this is the operation of the clutch. On one side it can clutch on to this one and it can transfer power to the shaft; how do you may understand that is transferring power to the shaft? It is keyed on to the shaft by a sliding device ok.

So, it can either come this way or that way. So, this is the table.

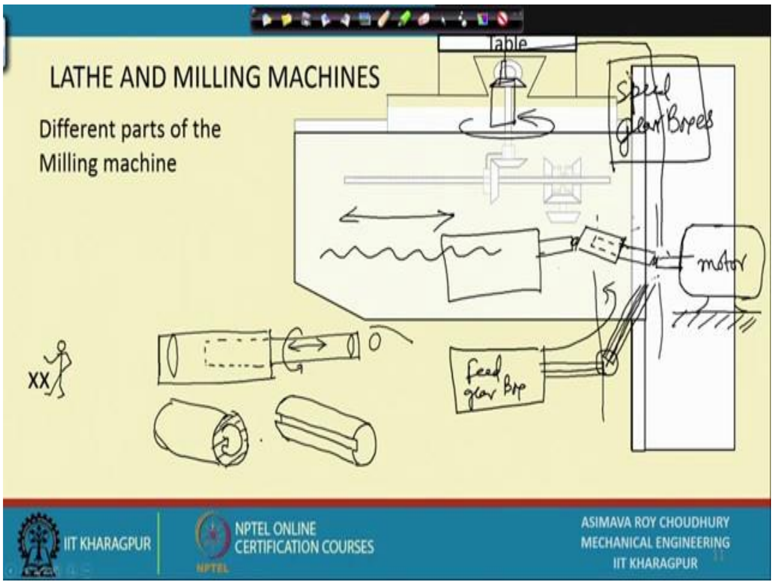


This is the the motion out of the plane is the one that we have discussed up till now, but the table also has motion in this direction. So, one motion we have discussed is out of the plane of the paper longitudinal motion, but it also has motion in this direction. Due to that the power going to the longitudinal slide you know has to always be in contact.

Because if you are moving this way; will not the power connection to the longitudinal slide come out of contact? So, for that we take a precaution; this is it ; that means, this shaft is having a sliding key so that these two bevel gears are always carried along with the motion which takes place for this slide this way; this is the cross direction let me just write down. Let me just go ahead and write here cross; what is that or transverse direction or cross direction. This is the you know longitudinal direction which we cannot see now, we are looking along the longitudinal direction.

So, this must be the screw of the longitudinal direction and that is what we have tried to show here this bevel gear brings in the power for that ok. Now let us have a quick look how cross direction works; the cross direction has to maintain contact between the longitudinal screw and the prime mover. So, if we have a screw here; this one will be always maintaining contact by making this assembly move; that it derives the power from this screw. So, let this derivation of power not be disturbed, this point and this screw should always be in contact.

So, that is done sorry that is done this way ok; this power contact, this connection is always traveling so, that this screw gets power. And the one you know choice of the direction of motion that is brought out here in order to make things simple ok.



Now we are miniaturizing that part now, we have already discussed the longitudinal direction, we have already discussed the cross direction movement. Now comes the up and down movement ok; up till now we have understood the power is flowing this way how does the longitudinal motion take place here? This is the movement that we have already seen now it is miniaturized. How is the up and down movement taking place? This whole thing moves up and down; let us see how it is done, that is it; this whole thing is moving up and down and therein we have a problem.

What is this problem? See let us take a hypothetical case that see in this place; we are having a motor and from this motor there is a shaft and from this shaft we are having say connection to another shaft here. And basically what is the concept? We have to bring power to this member because we have seen that it moves up and down; how does it move up and down? It drains power from a motor; where is that motor? It is here; you will say why do not we carry the motor on this one?

Generally, you will find that there are many milling machines ok; there are there are different types of milling machines, there are many milling machines; in which all the power for speed and feed, they are derived from a single motor. If that be so that motor should preferably be in a in a stationary place and from there cutting speed, you know the cutter is here. Cutter is here and the cutter must be deriving the power from this motor only what is there in between? Gear boxes so that we can change the speed of the cutter.

So, let me write here speed gearbox already gearbox we have had quite a look at gearboxes. So, I will not repeat everything we we we will just learned principles then you might say it must be having a feed gear box. Yes a feed gear box is here; a feed gearbox will be here and from there ultimately you will be deriving power this way; so, that completes the circle. After this we know all the things that we are that are supposed to exist; all that direction change. direction change all that rotation of the table about a vertical axis; all those things we have discussed, then movement of this one this way that way etcetera we have seen that.

So, now you might say where is the screw nut arrangement which is making this movement possible? Is it this screw? No it is not this one, there will be a separate screw and that will be given power ok; this way there will be a separate screw. So, now we are concerned about you know something else now; I want to get your attention to some other aspect what is that?

That aspect is this mortar is stationary. So, let us make it stationary; this shaft is stationary and maybe here you have used some sort of universal joints ok; some universal joints are used at this place and this place so that you are still able to though it is you know and not having the same axis, you are still able to transmit power this way. Problem occurs when this has moved up, when it moves up so let us quickly have that.

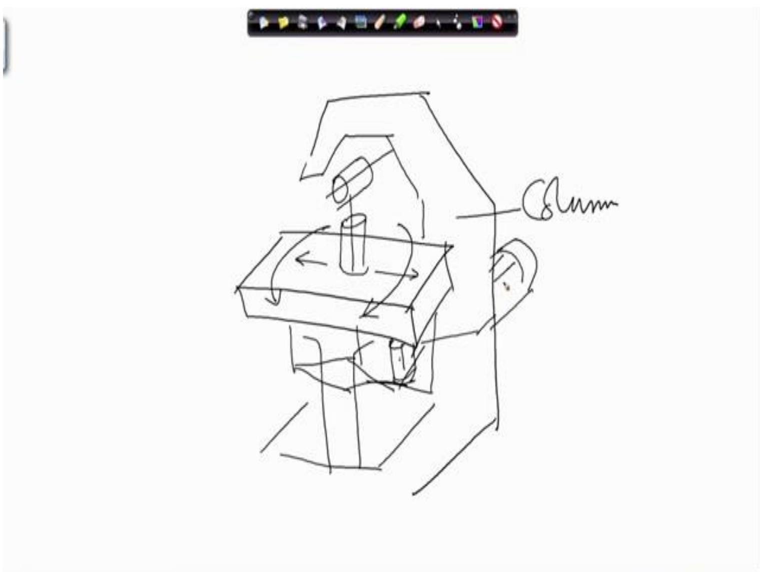
When it moves up, the problem is the connection is now different; the connection might be this way sorry the connection is now this way. So; obviously, if you take you know directly lines this distance is less than this one, now how can you know rigid shafts change their size?. So, for that something called a telescopic shaft is used here; telescopic shaft means you know if you remember the operation of the telescope, the telescope looks like this you know old telescopes.

Nowadays, maybe we do not deal with these telescopes now; this is your eye and maybe there is one lens here and lots of lenses might be there, but say there is another lens here. Now in order to focus upon a distant object, we can adjust the distance between these two lenses so, that this is movable; how is it movable? Maybe it is provided with a jacket, this is a sleeve and this is movable inside this sleeve. The same thing has to be done here and that is why it derives its name telescopic shaft. But you know if you give a rotation to this; if it is if there is nothing to stop the rotation, this will rotate; this side will rotate let me let me rub it out and actually draw a telescopic sort of link.

You know if we have such a member here that is; this is one part of the shaft and it is fitting on to another shaft. And then its linked here, it is linked here by universal joints please look up universal joints; they are very simple to understand, they allow rotation from between shafts which are not aligned along the same line.

So, if its rotate this still another problem; that is this might have you know this might rotate, but still this is not rotating because this is circular, that is circular there is no you know nothing to make this rotate. This is going inside, this one no problem and that way length is getting adjusted. So, what we have to do is; we have to at least provide one or two you know key ways on this or tooth spaces on this and fitting teeth on this one; so, that they will look like this.

This one looks this way alright; it has a depression and there is a fitting tooth on this one; there is a fitting tooth on this one. So, this problem of power transmission is solved by universal joints and telescopic shafts ok; if you have a single motor supplying every one. So, to sum up to sum up let us have a quick look what we have learnt today.



Today we have learnt about the milling machine which basically has a shape of this type; table, column, knee. Knee is basically housing that vertical screw which will provide us with you know up down motion. And this one may be having vertical motion because of which it will be called universal, if it has you know motion about a horizontal axis; it will call, it will be called universal that is a little rare; if that if the cutter axis is horizontal it is called a horizontal milling machine.

If the cutter axis is vertical; it is called a vertical milling machine, if if it is to have this you know rotational motion of the table; it has to have bevel gear connections which will allow it to rotate in order to choose between you know directions sense of motion for longitudinal or vertical or cross; we need a clutch. And in order to derive power from the main motor here, we need a telescopic shaft; a telescopic shaft is required.

So, this one is like this and somewhere here there will be that telescopic shaft by the side of the machine; universal joins with telescopic shafts ok. And last of all which I have not covered today; there might yet be another; another motor called rapid traverse motor, which can over ride; that means, it will be deciding what the motion of the table will be. Over ride the feed motions set and provide a faster motion to the table slides by a device called an over running clutch.

Why this required? If you want to rapidly position the job at some location, you cannot depend upon the slow machining feed rates which are available from the machine. There you put this motor on and apply the automatic motions that you require and the overrunning clutch will make it sure that the motion derived from this motor will prevail over the motions obtained from this one ok.

So, with that we come to the end of the sixteenth lecture on milling machines. Thank you very

much.

MODULE-V
Superfinishing processes, Honing,
Lapping and Superfinishing

Instructional Objectives

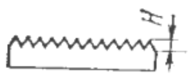
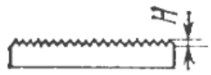
At the end of this lesson the students would be able to

(i) understand the significance of superfinishing process
(ii) state various applications of the superfinishing process
(iii) illustrate various techniques of superfinishing process

To ensure reliable performance and prolonged service life of modern machinery, its components require to be manufactured not only with high dimensional and geometrical accuracy but also with high surface finish. The surface finish has a vital role in influencing functional characteristics like wear resistance, fatigue strength, corrosion resistance and power loss due to friction. Unfortunately, normal machining methods like turning, milling or even classical grinding can not meet this stringent requirement.

Table 30.1 illustrates gradual improvement of surface roughness produced by various processes ranging from precision turning to superfinishing including lapping and honing.

Table 30.1

Process	Diagram of resulting surface	Height of micro irregularity (µm)
Precision Turning		1.25-12.50
Grinding		0.90-5.00
Honing		0.13-1.25
Lapping		0.08-0.25
Super Finishing		0.01-0.25

Therefore, superfinishing processes like lapping, honing, polishing, burnishing are being employed to achieve and improve the above-mentioned functional properties in the machine component.

Lapping

Lapping is regarded as the oldest method of obtaining a fine finish. Lapping is basically an abrasive process in which loose abrasives function as cutting points finding momentary support from the laps. Figure 30.1 schematically represents the lapping process. Material removal in lapping usually ranges from .003 to .03 mm but many reach 0.08 to 0.1mm in certain cases.

Characteristics of lapping process:

- Use of loose abrasive between lap and the workpiece
- Usually lap and workpiece are not positively driven but are guided in contact with each other
- Relative motion between the lap and the work should change continuously so that path of the abrasive grains of the lap is not repeated on the workpiece.

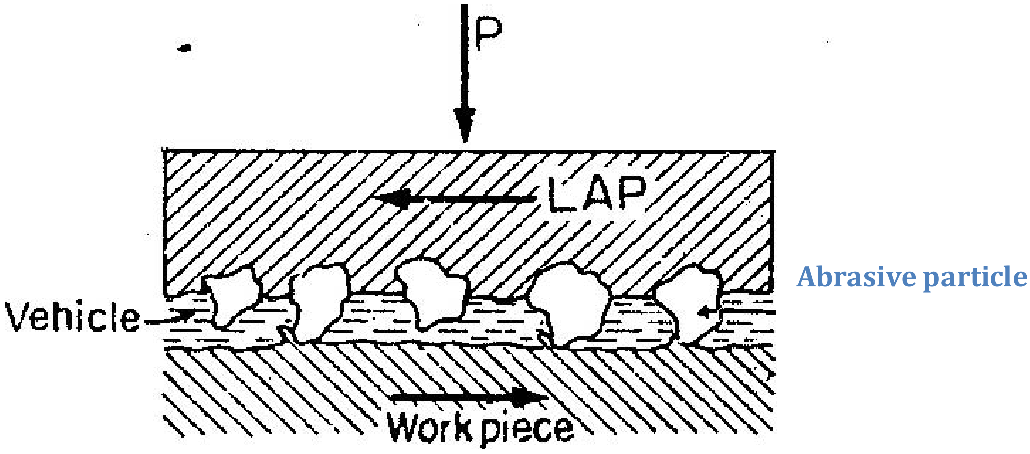


Fig. 30.1 *Scheme of lapping process*

Cast iron is the mostly used lap material. However, soft steel, copper, brass, hardwood as well as hardened steel and glass are also used.

Abrasives of lapping:

- Al_2O_3 and SiC, grain size 5~100μm
- Cr_2O_3, grain size 1~2 μm
- B_4C_3, grain size 5-60 μm
- Diamond, grain size 0.5~5 V

Vehicle materials for lapping

- Machine oil
- Rape oil
- grease

Technical parameters affecting lapping processes are:

- unit pressure
- the grain size of abrasive
- concentration of abrasive in the vehicle
- lapping speed

Lapping is performed either manually or by machine. Hand lapping is done with abrasive powder as lapping medium, whereas machine lapping is done either with abrasive powder or with bonded abrasive wheel.

Hand lapping

Hand lapping of flat surface is carried out by rubbing the component over accurately finished flat surface of master lap usually made of a thick soft close-grained cast iron block. Abrading action is accomplished by very fine abrasive powder held in a vehicle. Manual lapping requires high personal skill because the lapping pressure and speed have to be controlled manually.

Laps in the form of ring made of closed grain cast iron are used for manual lapping of external cylindrical surface. The bore of the ring is very close to size of the workpiece however, precision adjustment in size is possible with the use of a set screw as illustrated in Fig.30.2(a). To increase range of working, a single holder with interchangeable ring laps can also be used. Ring lapping is recommended for finishing plug gauges and machine spindles requiring high precision. External threads can be also lapped following this technique. In this case the lap is in the form of a bush having internal thread.

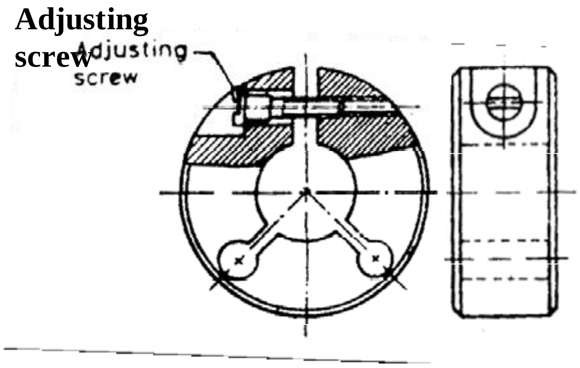


Fig. 30.2 Manual Ring lapping of external cylindrical surface

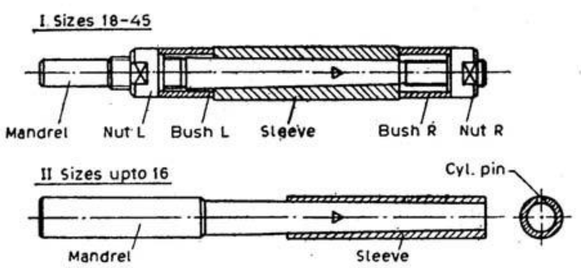


***Fig. 30.2** (b) Manual Lapping of internal cylindrical surfaces*

Solid or adjustable laps, which are ground straight and round, are used for lapping holes. For manual lapping, the lap is made to rotate either in a lathe or honing machine, while the workpiece is reciprocated over it by hand. Large size laps are made of cast iron, while those of small size are made of steel or brass. This process finds extensive use in finishing ring gauges.

Lapping Machine

Machine lapping is meant for economic lapping of batch qualities. In machine lapping, where high accuracy is demanded, metal laps and abrasive powder held in suitable vehicles are used. Bonded abrasives in the form wheel are chosen for commercial lapping. Machine lapping can also employ abrasive paper or abrasive cloth as the lapping medium. Production lapping of both flat and cylindrical surfaces are illustrated in Fig. 30.3 (a) and (b). In this case cast iron plate with loose abrasive carried in a vehicle can be used. Alternatively, bonded abrasive plates may also be used. Centreless roll lapping uses two cast iron rolls, one of which serves as the lapping roller twice in diameter than the other one known as the regulating roller. During lapping the abrasive compound is applied to the rolls rotating in the same direction while the workpiece is fed across the rolls. This process is suitable for lapping a single piece at a time and mostly used for lapping plug gauges, measuring wires and similar straight or tapered cylindrical parts.

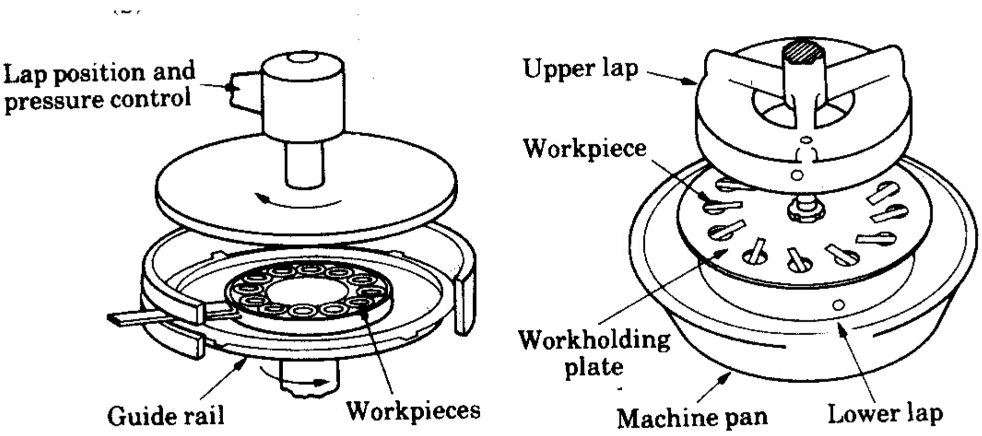


Fig.30.3 *Production lapping on (a) flat surface (b) cylindrical surface*

Centreless lapping is carried out in the same principle as that of centreless grinding. The bonded abrasive lapping wheel as well as the regulating wheel are much wider than those used in centreless grinding. This technique is used to produce high roundness accuracy and fine finish, the workpiece requires multi-pass lapping each with progressively finer lapping wheel. This is a high production operation and suitable for small amount of rectification on shape of workpiece. Therefore, parts are to be pre-ground to obtain substantial straightness and roundness. The process finds use in lapping piston rings, shafts and bearing races.

Machines used for lapping internal cylindrical surfaces resembles honing machines used with power stroke. These machines in addition to the rotation of the lap also provide reciprocation to the workpiece or to the lap. The lap made usually of cast iron either solid or adjustable type can be conveniently used.

Figure 30.4 shows that to maximize the MRR (material removal rate) an optimum lapping pressure and abrasive concentration in the vehicle have to be chosen.

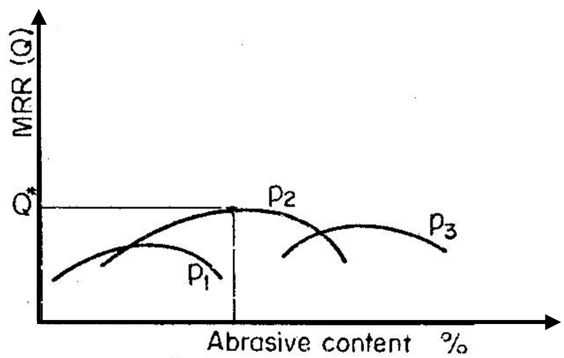


Fig. 30.4 *Effect of abrasive content on MRR*

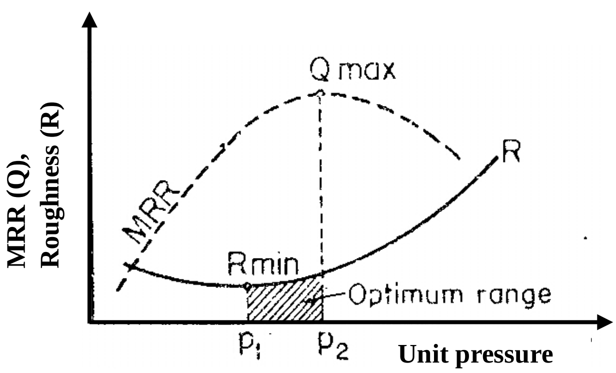


Fig. 30.5 *Effect of lapping pressure on surface roughness and MRR*

The effect of unit pressure on MRR and surface roughness is shown in Fig. 30.5. It is shown in the same figure that unit pressure in the range of p_1-p_2 gives the best values for MRR and roughness of the lapped surface.

The variation in MRR and surface roughness with grain size of abrasive are shown in Fig.30.6. It appears that grain size corresponding to permissible surface roughness and maximum MRR may be different. Primary consideration is made on the permissible surface roughness in selecting abrasive grain size.

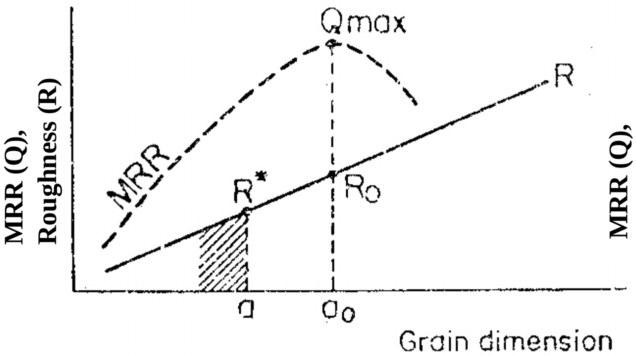


Fig. 30.6 *Effect of abrasive grain size on surface roughness and MRR*

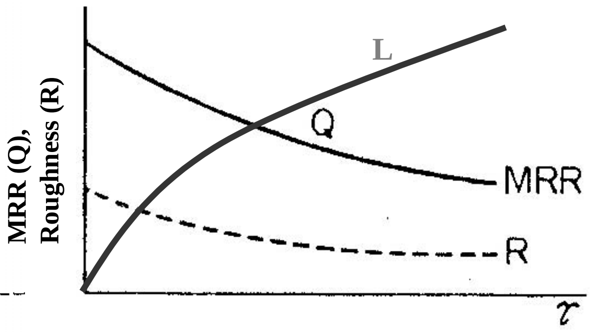


Fig. 30.7 *Effect of lapping time on surface roughness and MRR*

The dependence of MRR, surface roughness and linear loss (L) of workpiece dimension is shown in fig. 30.7. Lapping conditions are so chosen that designed surface finish is obtained with the permissible limit of linear loss of workpiece dimension as shown in Fig. 30.8.

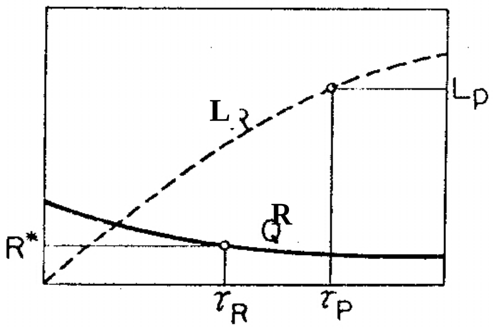


Fig. 30.8 *Criteria for choosing lapping time*

Honing

Honing is a finishing process, in which a tool called hone carries out a combined rotary and reciprocating motion while the workpiece does not perform any working motion. Most honing is done on internal cylindrical surface, such as automobile cylindrical walls. The honing stones are held against the workpiece with controlled light pressure. The honing head is not guided externally but, instead, floats in the hole, being guided by the work surface (Fig. 30.9). It is desired that

1. honing stones should not leave the work surface
2. stroke length must cover the entire work length.

In honing rotary and oscillatory motions are combined to produce a cross hatched lay pattern as illustrated in Fig. 30.10

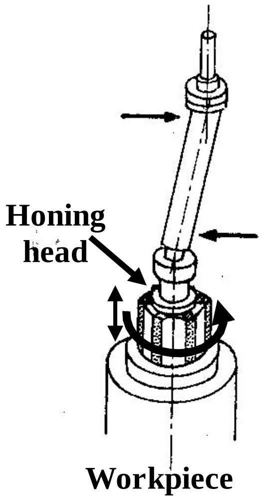


Fig. 30.9 *Honing tool*

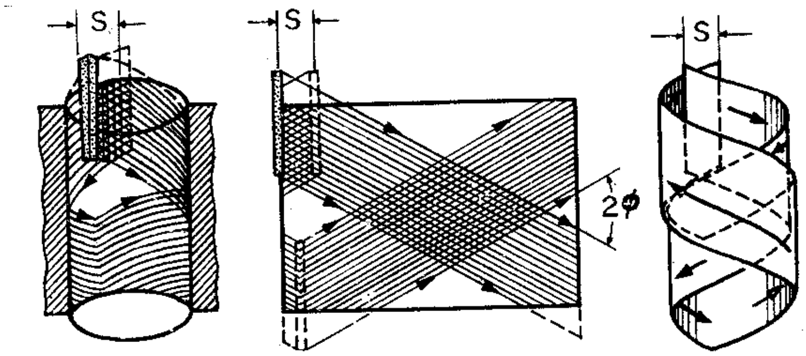


Fig. 30.10 *Lay pattern produced by combination of rotary and oscillatory motion*

The honing stones are given a complex motion so as to prevent every single grit from repeating its path over the work surface. The critical process parameters are:

1. rotation speed
2. oscillation speed
3. length and position of the stroke
4. honing stick pressure

With conventional abrasive honing stick, several strokes are necessary to obtain the desired finish on the work piece. However, with introduction of high performance diamond and cBN grits it is now possible to perform the honing operation in just one complete stroke. Advent of precisely engineered microcrystalline cBN grit has enhanced the capability further. Honing stick with microcrystalline cBN grit can maintain sharp cutting condition with consistent results over long duration.

Superabrasive honing stick with monolayer configuration (Fig. 30.11), where a layer of cBN grits are attached to stick by a galvanically deposited metal layer, is typically found in single stroke honing application.

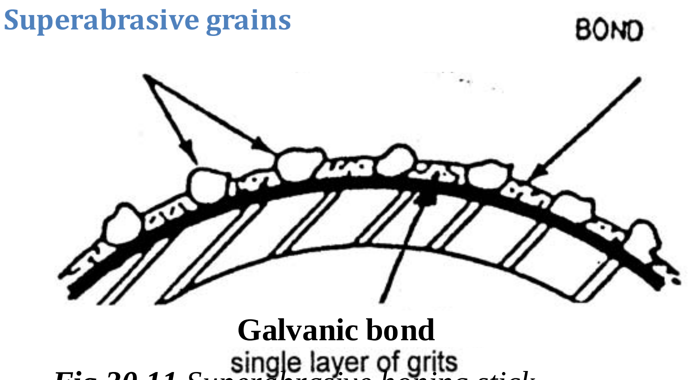


Fig.30.11 *Superabrasive honing stick with single layer configuration*

With the advent of precision brazing technique, efforts can be made to manufacture honing stick with single layer configuration with a brazed metal bond. Like brazed grinding wheel such single layer brazed honing stick are expected to provide controlled grit density, larger grit protrusion leading to higher material removal rate and longer life compared to what can be obtained with a galvanically bonded counterpart.

The important parameters that affect material removal rate (MRR) and surface roughness (R) are:

(i) unit pressure, p
(ii) peripheral honing speed, Vc
(iii) honing time, T

The variation of MRR (Q) and R with unit pressure is shown in Fig. 30.12. It is evident from the graph that the unit pressure should be selected so as to get minimum surface roughness with highest possible MRR.

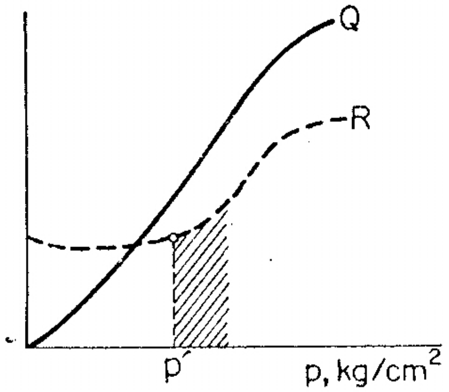


Fig. 30.12*: Effect of honing pressure on MRR and surface finish*

Figure 30.13 shows that an increase of peripheral honing speed leads to enhancement of material removal rate and decrease in surface roughness.

Figure 30.14 shows that with honing time T, MRR decreases. On the other hand, surface roughness decreases and after attaining a minimum value again rises. The selection of honing time depends very much on the permissible surface roughness.

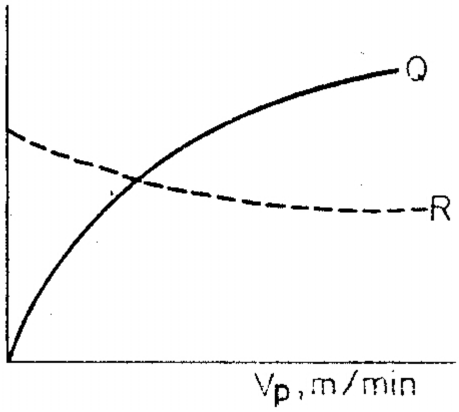


Fig. 30.13 *Effect of peripheral honing speed*

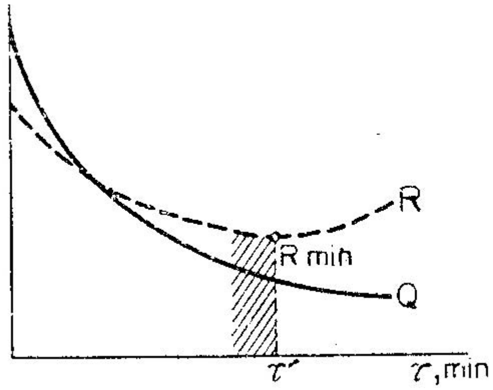


Fig. 30.14 *Effect of honing time on material removal rate and surface roughness*

Superfinishing

Figure 30.15 illustrates superfinishing end-face of a cylindrical workpiece. In this both feeding and oscillation of the superfinishing stone is given in the radial direction.

Figure 30.16 shows the superfinishing operation in plunge mode. In this case the abrasive stone covers the section of the workpiece requiring superfinish. The abrasive stone is slowly fed in radial direction while its oscillation is imparted in the axial direction.

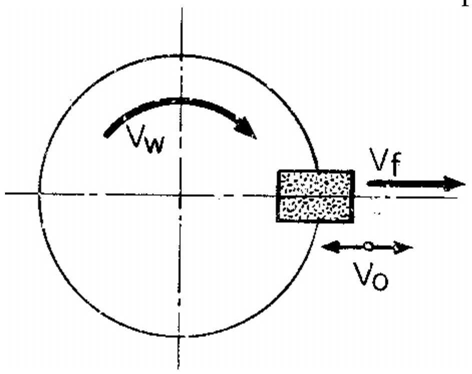


Fig. 30.15 *superfinishing of end face of a cylindrical work piece in radial mode*

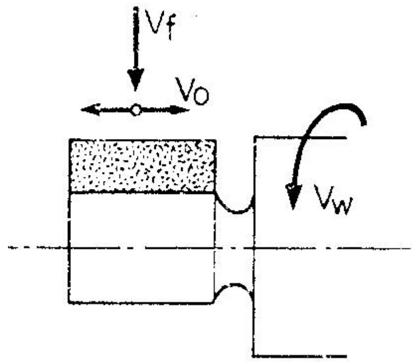


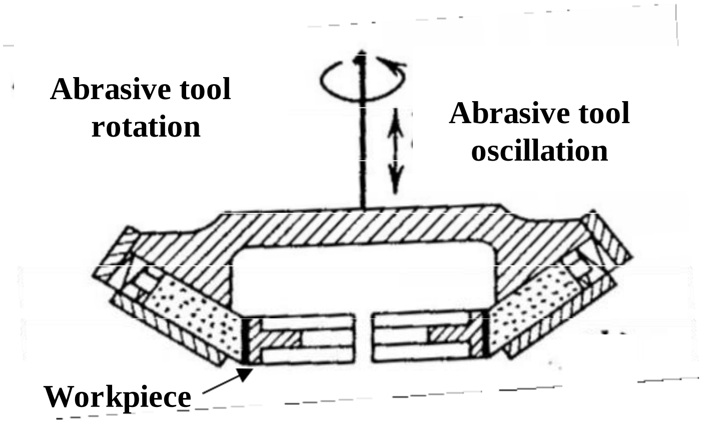
Fig. 30.16 *superfinishing operation in plunge mode*

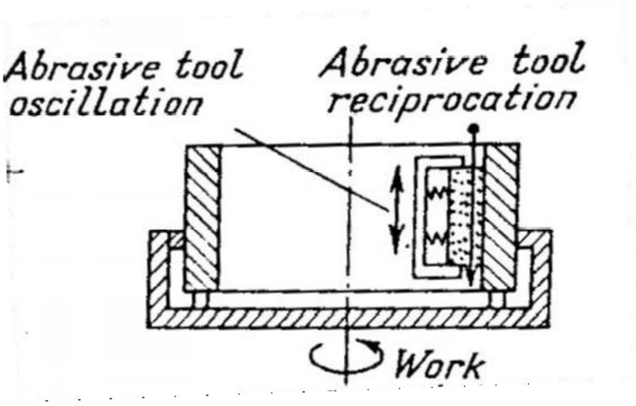
Superfinishing can be effectively done on a stationary workpiece as shown in Fig. 30.17. In this the abrasive stones are held in a disc which oscillates and rotates about the axis of the workpiece.

Fig. 30.18 shows that internal cylindrical surfaces can also be superfinished by axially oscillating and reciprocating the stones on a rotating workpiece.

Abrasive tool oscillation

Abrasive tool reciprocation





Abrasive tool oscillation

Workpiece

Fig. 30.17 Abrasive tool rotating and oscillating about a stationary workpiece

Fig. 30.18 Superfinishing of internal surface

Burnishing

The burnishing process consists of pressing hardened steel rolls or balls into the surface of the workpiece and imparting a feed motion to the same. Ball burnishing of a cylindrical surface is illustrated in Fig. 30.19.

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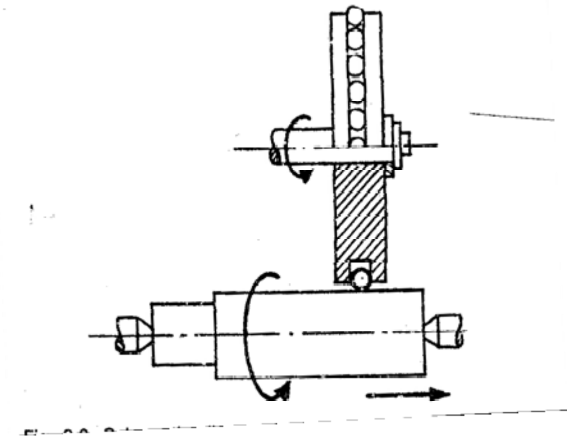

Fig. 30.19 *Scheme of ball burnishing*

During burnishing considerable residual compressive stress is induced in the surface of the workpiece and thereby fatigue strength and wear resistance of the surface layer increase.

Magnetic float polishing

Magnetic float polishing (Fig.30.20) finds use in precision polishing of ceramic balls. A magnetic fluid is used for this purpose. The fluid is composed of water or kerosene carrying fine ferro-magnetic particles along with the abrasive grains. Ceramic balls are confined between a rotating shaft and a floating platform. Abrasive grains ceramic ball and the floating platform can remain in suspension under the action of magnetic force. The balls are pressed against the rotating shaft by the float and are polished by their abrasive action. Fine polishing action can be made possible through precise control of the force exerted by the abrasive particles on the ceramic ball.

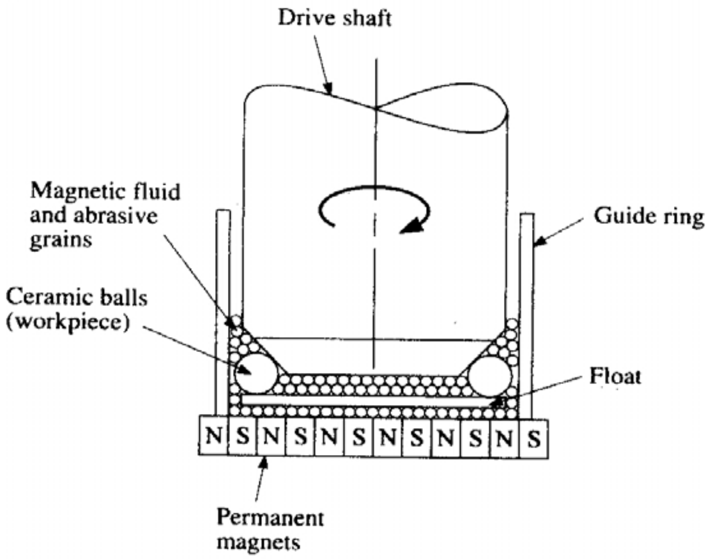

Fig. 30.20 *Scheme of magnetic float polishing*

Magnetic field assisted polishing

Magnetic field assisted polishing is particularly suitable for polishing of steel or ceramic roller. The process is illustrated schematically in Fig. 30.21. A ceramic or a steel roller is mounted on a rotating spindle. Magnetic poles are subjected to oscillation, thereby, introducing a vibratory motion to the magnetic fluid containing this magnetic and abrasive particles. This action causes polishing of the cylindrical roller surface. In this technique, the material removal rate increases with the field strength, rotational speed of the shaft and mesh number of the abrasive. But the surface finish decreases with the increase of material removal rate.

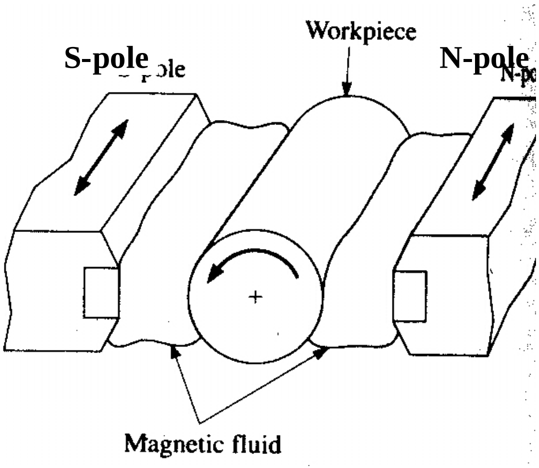

Fig. 30.21 *scheme of magnetic field assisted polishing*

Electropolishing

Electropolishing is the reverse of electroplating. Here, the workpiece acts as anode and the material is removed from the workpiece by electrochemical dissolution. The process is particularly suitable for polishing irregular surface since there is no mechanical contact between workpiece and polishing medium. The electrolyte electrochemically etches projections on the workpiece surface at a faster rate than the rest, thus producing a smooth surface. This process is also suitable for deburring operation.

Exercise 30

Q1: How is the size of the abrasive grain chosen?

Q2: Can CBN be used in honing stick in single layer configuration? Q3:

How does super finishing differ from honing?

Q4: State the advantage of electro polishing over mechanical polishing. Q5:

How is the surface quality improved in ball burnishing?

Ans1:
Size of the abrasive grain is chosen keeping in view, the permissible roughness of the workpiece and maximum material removal rate attainable.

Ans2:
cBN grits in single layer configuration embedded in galvanic bond can be effectively used as honing stick. Such honing stick is preferred in production honing with just a single stroke operation.

Ans3:
Super finishing, in a way, is similar to honing but with very low cutting pressure and different kinematic tool-work interactions like

- oscillatory motion of the abrasive stick with short stroke but with high frequency.
- rotation of work piece is usually kept low.
- feed motion of the tool or the work piece.

Ans4:
Electro polishing has clear advantage in polishing irregular surfaces. The electrolyte attacks high points at a faster rate than rest of the surface resulting in production of a smooth surface.

Ans5:
In this process, a hardened steel ball presses the workpiece surface. The surface finish is markedly improved. In addition, a residual compressive stress is developed on the surface, which in turn improves the fatigue resistance. The work hardening effect, as a result of burnishing, also enhances wear resistance of the surface. Therefore, by ball burnishing the overall quality of the workpiece surface is significantly improved.