MODULE 5

Module 5

Lathe: *Principle of working of a center lathe. Parts of a lathe. Operations on lathe - Turning, Facing, Knurling, Thread Cutting, Drilling, Taper turning by Tailstock offset method and Compound slide swiveling method, Specification of Lathe.*

Milling Machine: *Principle of milling, types of milling machines. Working of horizontal and vertical milling machines. Milling processes - plane milling, end milling, slot milling, angular milling, form milling, straddle milling, and gang milling.*
(Layout sketches of the above machines need not be dealt. Sketches need to be used only for explaining the operations performed on the machines)

Computer Numerical Control (CNC): *Introduction, components of CNC, open loop and closed loop systems, advantages of CNC, CNC machining centers and Turning centers.*

Robots: *Robot anatomy, joints and links, common robot configurations. Applications of Robots in material handling, processing and assembly and inspection.*

Lathe and Milling operations

Cutting tools: Tools which are used to separate/remove material stock from the work piece are known as cutting tools. Ex hack saw, chisel etc.

Machine tools: Machine tools are power driven cutting tools or machines which enable the removal of excess stock of material from the work piece.
The fundamental machine tools that are used for most of the machining processes are *Lathe, Drilling, Tapping, Milling and Grinding machines.*

Lathe
Lathe is a machine tool which is used to produce the circular objects. It is said to be the mother of all machine tools since almost all machining operation which are performed on other machine tools like drilling, grinding, milling and shaping etc. can be performed on it.
Depending on their characteristic functions lathes are classified as 1) Engine lathe 2) Speed lathe 3) Turret lathe 4) Capstan lathe 5) Automatic lathe 6) Computer numerically controlled (CNC) lathe.

Parts of a Lathe
The Lathe consists of the following parts.
1. Bed
2. Head stock
3. Tail stock
4. Lead screw
5. Feed rod
6. Carriage
   a. Saddle
   b. Cross slide
   c. Compound rest
   d. Tool post

Figure 1: Lathe

Working principle of Lathe

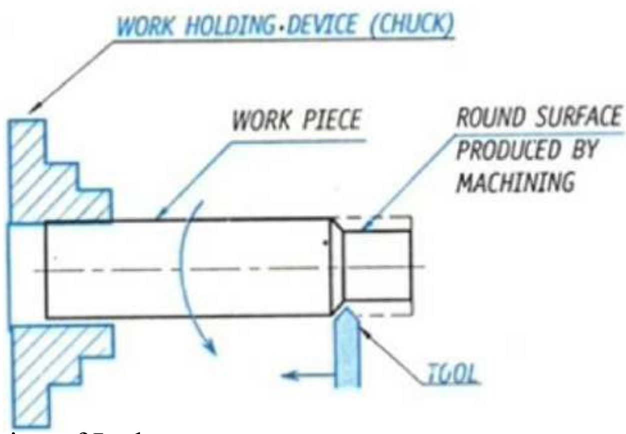


Fig 1: Principle of working of Lathe

Lathe is basically a turning machine, works on the principle that a cutting tool can remove material in the form of chips from the rotating work piece to produce circular objects. Figure 1 shows a work piece is hold firmly in the work holding device called the chuck and is rotated at a very high speed. The cutting tool held against the rotating work piece opposite to its direction of rotation when moved parallel to the axis of the work piece produces circular surfaces.

Lathe Specifications

1. Maximum diameter of the workpiece can be revolved over the Lathe bed.
2. The maximum diameter and the width of the workpiece that can swing when the lathe has a gap bed.
3. The maximum length of the workpiece that can be mounted between the centers.
4. Overall length of the bed.

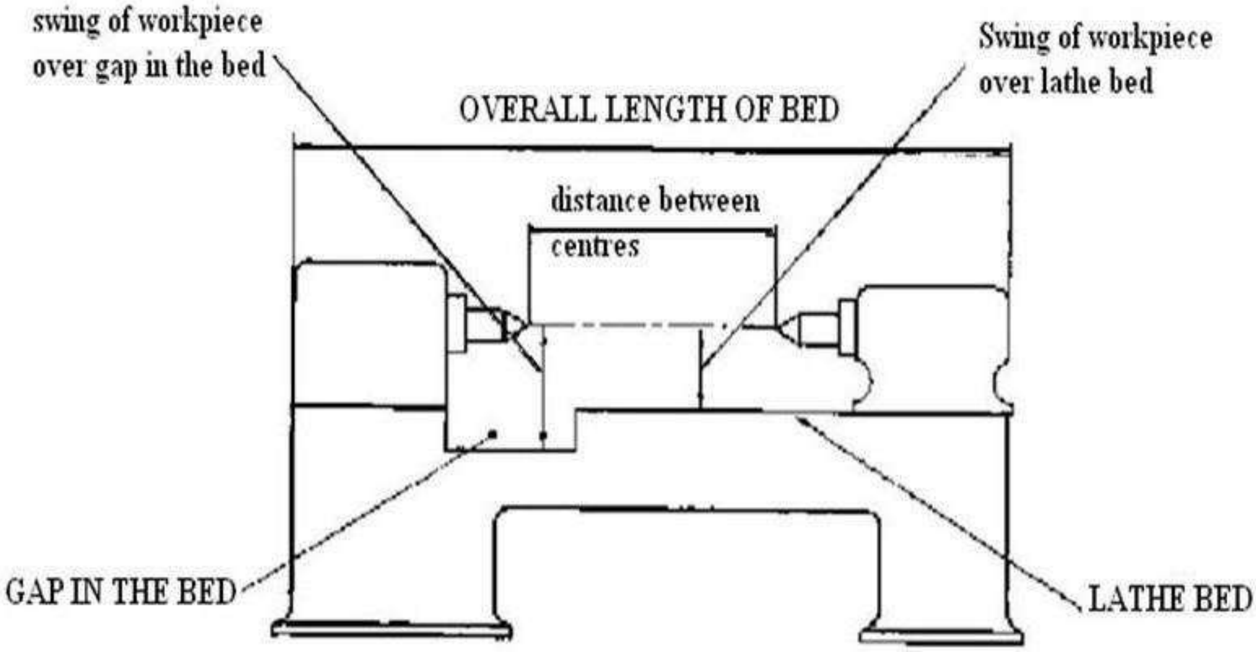
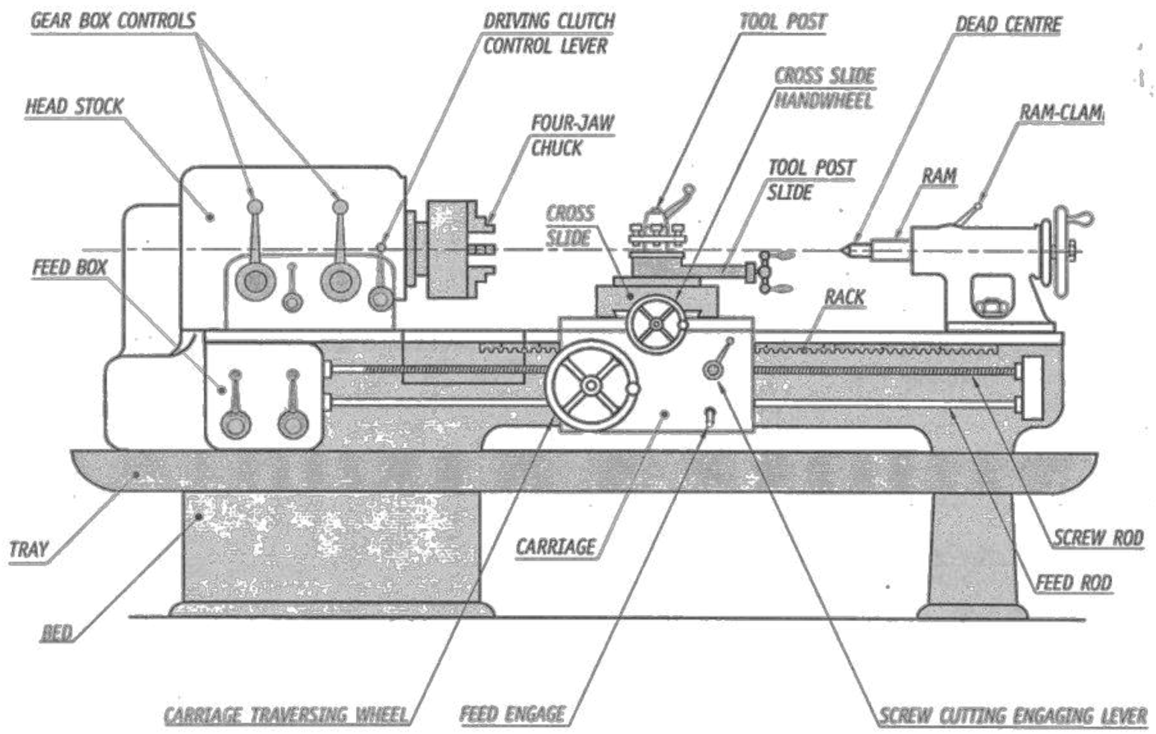


Figure 2: Specification of Lathe

Lathe and its parts:



Schematic Diagram of Lathe

1. Bed: The bed is the foundation part of a lathe and supports all its other parts. The top of the bed is formed by precision machined guide ways. There will be two sets of guide ways, viz., outer ways and inner ways. The headstock and the tail stock are mounted on the inner ways which keep them perfectly aligned with each other. The outer ways guide the longitudinal movement of the carriage assembly and align it with the center line of the lathe.

2. Main Drive: An electric motor mounted in the left leg of the lathe in conjunction with the transmission system like belt or gear drive from the motor to the spindle that form the main drive of the lathe.

3. Cone Pulley and Back Gear: The cone pulley which drives the main spindle through belting is driven by the motor. Various spindle speeds can be obtained by shifting the belt on the different steps of the cone pulley. Spindle speeds can be further varied using a back gear arrangement.

4. Head stock: The housing comprising of the feed gear box and the cone pulley is called headstock of the lathe. The main spindle projects out from the headstock. The headstock will be rigidly mounted on the lathe bed at its left end.

5. Tail stock: Tailstock is the movable part of the lathe that carries the dead centre in it. The main function of the tailstock is to support the free end of the long work pieces. It is also used to clamp the tools like twist drills and reamers for making holes, and taps and dies for cutting threads. Tailstock is mounted loosely on the lathe bed ways and can be moved and locked in any desired position.

6. Carriage Assembly: The carriage assembly serves to support the tool and rides over the bed ways longitudinally between the headstock and tailstock. It is composed of five main parts: 1. Saddle, 2. Cross Slide, 3. Compound Rest, 4. Apron, and 5. Tool Post.

Saddle is an H shaped casting that slides over the outer set of the guide ways and serves as the base for the cross slide.

Cross Slide is mounted on the saddle and enables the movement of the cutting tool laterally across the lathe bed by means of cross-feed hand wheel. It also serves as the support for a compound rest.

Compound Rest is mounted on the top of the cross slide and supports the tool post. It can be swivelled to any angle in the horizontal plane to facilitate the taper turning and threading Operations. It is moved manually by the compound rest feed handle independent of the lathe cross feed.

Apron is mounted at the front of the saddle beneath it and houses the carriage and the cross slide mechanisms. The apron hand wheel moves the carriage assembly manually by means of the rack and the pinion gears.

Tool Post is mounted in the T slot of the compound rest. The tool post clamps the tool holder in the proper position for machining operations.

7. Lead Screw: Lead screw is a screw rod which runs longitudinally in front of the lathe bed. The rotation of the lead screw moves the carriage to and fro longitudinally during thread cutting operations.

8. Feed Rod: The feed rod is a stationary rod mounted in front of the lathe bed and facilitates longitudinal movement of the carriage during turning, boring and facing operations.

9. Feed Gear Box: The feed gear box is mounted on the left side of the lathe bed and below the headstock. It houses the necessary gears and other mechanisms that transmit various feed gear ratios from the headstock spindle to either the lead screw or the feed rod.

Lathe Operations

The lathe is the most versatile general-purpose machine tool. It is capable to perform a large variety of operations.

Following are a few operations that can be performed on a lathe:

1. Facing	5. Knurling
2. Plain turning	6. Drilling
3. Taper turning	7. Boring
4. Thread cutting	8. Reaming

1. Facing

Facing is an operation performed on lathe to generate either flat surfaces or shoulders at the end of the workpiece. Operation is shown in fig. 2.

In facing operation the direction of feed given is perpendicular to the axis of the lathe. The workpiece is held in the chuck and the facing tool is fed either from the outer edge of the workpiece progressing towards the centre or from the centre of workpiece to the outer edge. The cutting tool is held by a tool holder in tool post. For rough cutting the tool can be fed either from outer edge to centre of workpiece or vice versa, but for finishing cuts the tool should fed from centre of workpiece to outer edge.

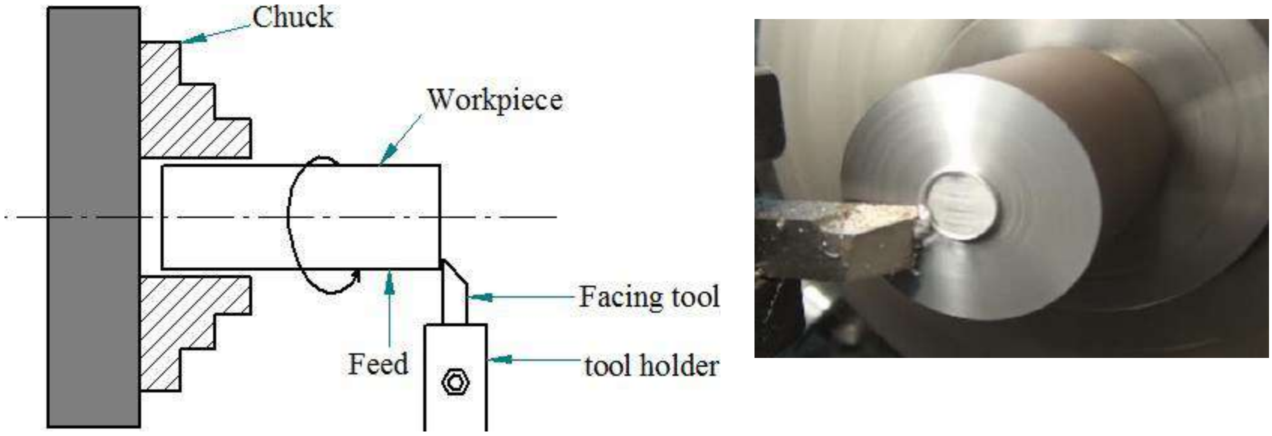


Fig 2: Facing Operation

2. Plain Turning

Turning is a lathe operation in which the cutting tool removes metal from the outside diameter of a workpiece. In other words, reduction in the diameter of the workpiece is called turning.

A single point cutting tool is fed perpendicular to the axis of the workpiece to a known predetermined depth of cut, and is then moved parallel to the axis of the workpiece. This operation will cut the material which comes out as shown in figure 3. The workpiece is reduced to the cylindrical section of required diameter.

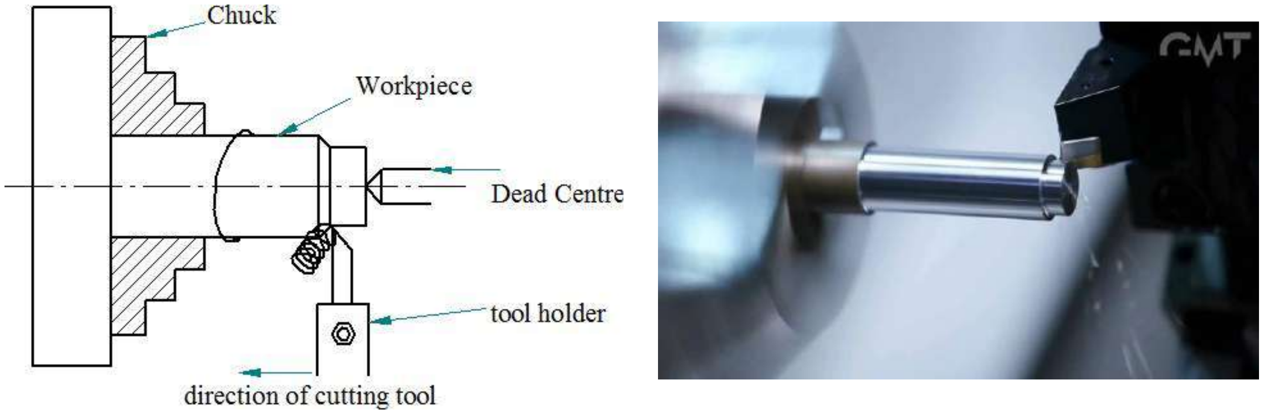


Fig 3: Turning operation

3. Taper Turning

Taper turning is an operation on lathe to produce conical surface on the workpiece.

Taper turning on a lathe is done by feeding the cutting tool at an angle to the axis of rotation the workpiece. A taper is a uniform increase or decrease in the diameter of the workpiece along its length. It can be achieved by either a) Swiveling the compound rest b) Offsetting the Tailstock

a) Taper turning by Swiveling the Compound rest

The work piece is rotated on lathe axis .The cutting tool mounted on the compound rest is attached to a circular base which can be swiveled and locked at any desired taper angle as shown in Fig 4. Compound rest may be swiveled at either side of the lathe. When the compound rest set at the desired taper angle is moved against the workpiece the cutting tool generates the required tapered surface on the workpiece. As the compound tool rest has only limited movement, this method can generate only short tapers.

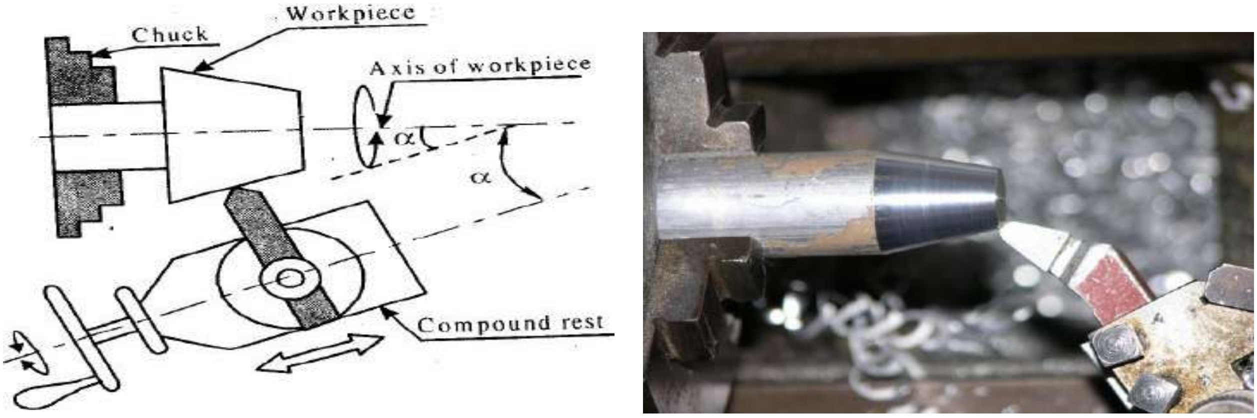


Fig.4: Taper turning by Swiveling the Compound rest

b) Taper turning by Offsetting the Tailstock

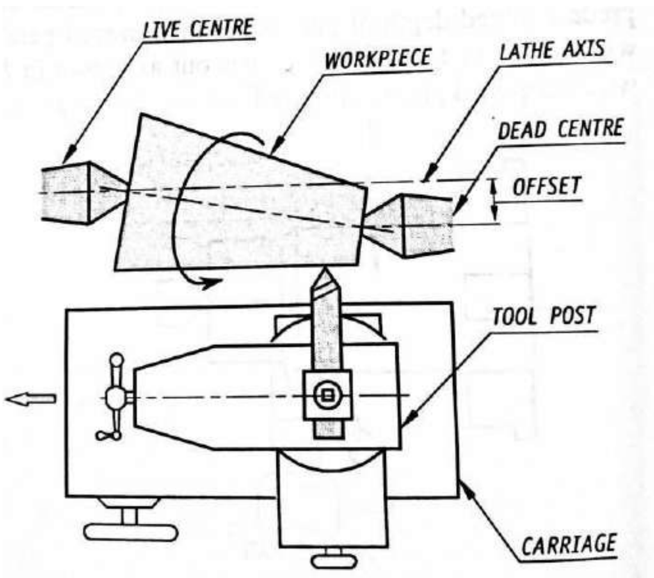


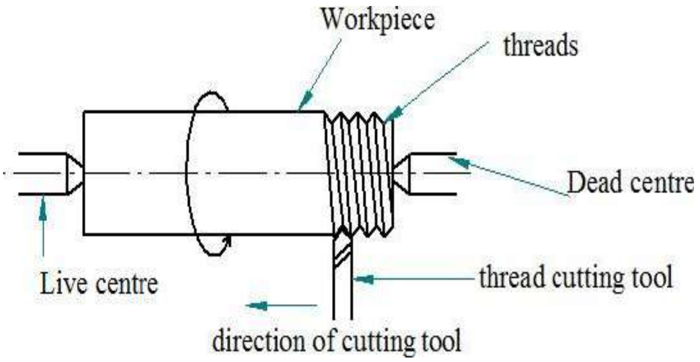
Figure 5: Taper turning by Offsetting the Tailstock

This method is also called as the set over tailstock method. It is the most commonly method employed for taper turning. When the tailstock centre is set out of alignment, the workpiece gets taper turned because its axis will be inclined at an angle with the longitudinal movement of the tool which will be parallel to the lathe bed. The entire carriage is to be moved parallel to the lathe bed to cut the taper. Since the amount of offset is limited by the size of the tailstock, this method is more suitable for jobs having less taper. As the carriage is moved to cut the taper, it will be possible to produce taper on the long workpieces. This method is best suited for long workpieces having less taper. Only external tapers can be produced by this method.

4. Thread cutting

A thread is a helical ridge formed on the cylindrical or conical rod. Thread cutting is an operation to generate V-threads or square threads of desired hand (right or left) and pitch on a workpiece using a suitable thread cutting tool.

In thread cutting operation the workpiece is held between live centre and dead centre. The thread cutting operation is performed on a lathe when a tool ground to shape of thread is moved longitudinally with uniform linear motion while the workpiece is rotating with uniform speed as shown in the figure 5. By maintaining an appropriate gear ratio between the spindle on which the workpiece is mounted and the lead screw which enables the tool to move longitudinally at the appropriate linear speed, the screw thread of the required pitch can be cut.



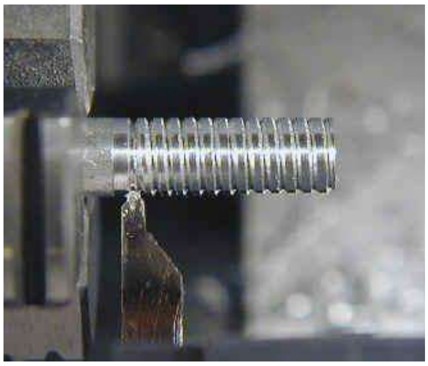
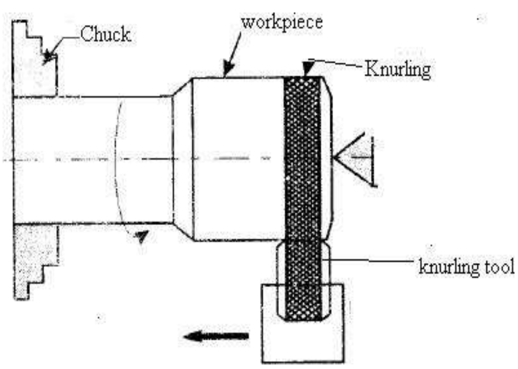


Fig. 5: Thread Cutting

5. Knurling

Knurling is an operation performed on lathe to generate serrated surfaces on workpiece by using special type of tool called knurling tool which impresses its pattern on the workpiece. A typical knurling tool consists of one upper roller and one lower roller on which the desired impression pattern can be seen.

The knurling tool is set in the tool post in such a way that the upper and roller rollers of the knurling head touches the surface of the workpiece to be knurled. The axis of the knurling head will be parallel to the axis of workpiece as shown in fig. 6. Usually a low speed is prescribed for knurling operation. Knurling is used for application where grip is required to hold the part.



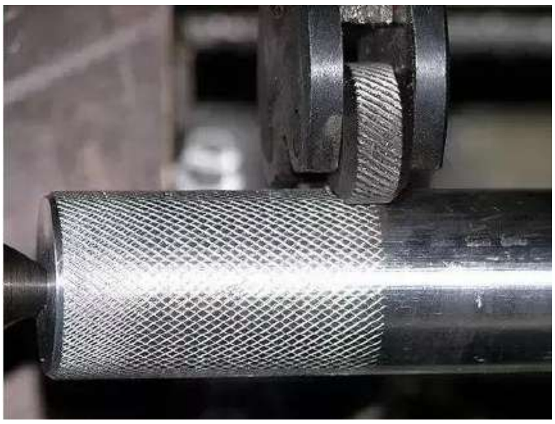


Fig. 6: Knurling operation

6. Drilling

Drilling is am machining operation of producing cylindrical hole in a solid workpiece by means of a revolving tool called drill bit.

Drilling operation is carried out on lathe machine is shown in figure 7. Initially the workpiece is held in a chuck and a drill bit having spiral shaped cutting edge is mounted on the tail stock. The workpiece is made to rotate at specified speed and the drill bit is moved parallel to the axis of rotation of the workpiece. The cutting edge of the drill bit will remove the material from the workpiece and produce cylindrical hole inside the workpiece.

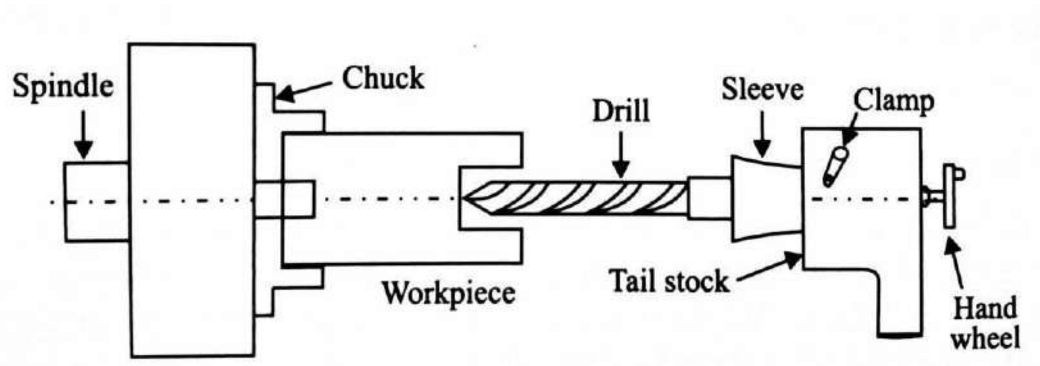


Figure 7: Drilling operation

Milling Machine

Milling is a machining process in which the metal cutting takes place with the help of a rotating multi-point cutter called milling cutter. Here the job is held stationary and fed against a rotating tool. The cutter has multiple cutting edges and it rotates at high speed. The machining takes place at a much faster rate and generally a good surface finish is obtained.

The machine tools employed for various milling operations are called milling machines. Milling machines are quite versatile and can do several operations like making flat surfaces, grooving, thread and gear cutting.

Working Principle of Milling Machine

The milling cutter is attached to a horizontal rotating shaft known as arbor. The work piece which clamped on the table is fed in the direction opposite to the milling cutter (up milling) or in the same direction of the milling cutter (down milling) The metal is removed by advancing the workpiece during each revolution of the rotating cutter in the form of chips. The milling operation is extensively used in machining flat surfaces contoured surfaces external & internal threads, helical surfaces of various cross sections.

Depending upon relative feed direction of worktable and rotation of cutter two different methods of milling is possible.

1. Conventional milling or Up milling
2. Climb milling or Down milling

1. Conventional milling or Up milling

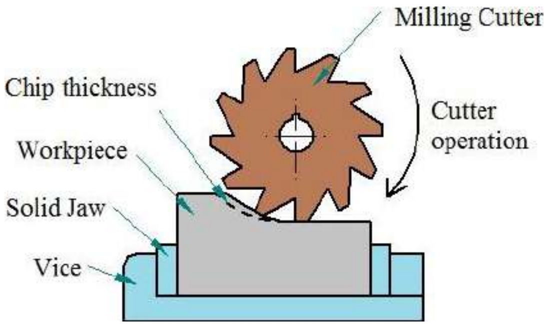


Fig 8: Up milling (conventional)

In up-milling, the chip thickness varies from a minimum at the tooth entrance to a maximum at the tooth exit as shown in figure 8. The forces produced by the cutting tool tend lift the work piece up from the table. Hence conventional milling process requires heavy work holding devices. Up milling leads to poor surface finish, due to vibrations developed by cutting forces of the cutter.

2. Down milling or Climb milling

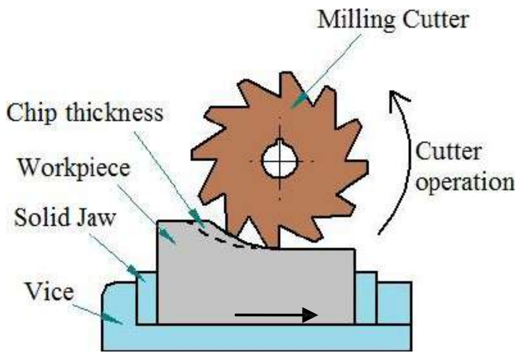


Fig 9: Down milling (climb)

In down milling, the metal is removed by the rotating cutter fed in the direction of movement of the workpiece as shown in figure 9. In down milling, the chip thickness varies from a maximum near the tooth entrance to a minimum near the tooth exit. Thus the cutting tooth is subjected to a maximum load from the very beginning. The cutting forces in down milling tend to act downwards, forcing the workpiece into the fixture or the vice. Hence the down milling process doesn't require heavier work holding devices. This type of milling produces higher surface finish compared to up milling.

Comparison between Up milling and Down milling

Sl. No	Up milling	Down milling
1	Work piece is fed in opposite direction of that of cutter.	Work piece is fed in same direction of that of cutter.
2	Chips are progressively thicker.	Chips are progressively thinner.
3	Strong clamping is required since the cutting force is directed upwards and tends to lift the work piece.	Strong clamping is not required since the cutting force is directed downwards and keeps work piece pressed to table.
4	Poor surface finish and used for hard materials	Good surface finish and used for soft materials.

Types of Milling Machine

The milling machines are broadly classified into
1) Plain or Horizontal Milling Machine
2) Vertical Milling Machine
3) Universal Milling Machine

Working of horizontal and vertical milling machines

Horizontal Milling Machine

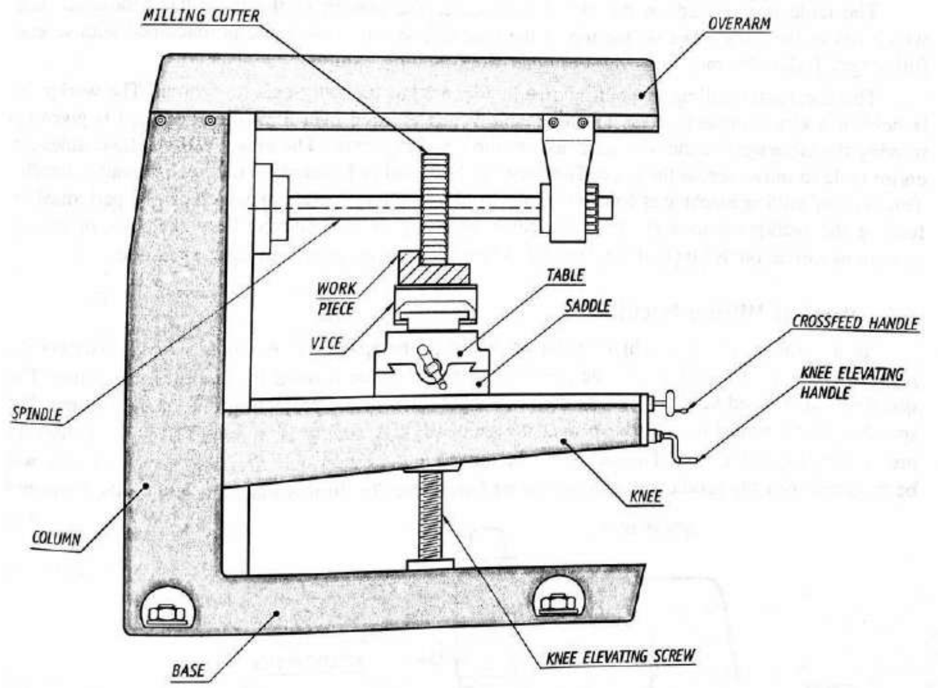


Figure 10: Horizontal Milling Machine

Different parts of a horizontal milling machine are 1) column 2) spindle 3) arbor 4) knee 5) saddle 6) table.
In horizontal milling machine the spindle is mounted with its axis horizontal to the work table. The column and the base are formed into an integral casting. The spindle head is fitted horizontally in the guide-ways provided in the column. The workpiece is held in a vice mounted on the machine table which is fitted over a saddle. The feed is given by moving the table against the horizontal axis of the revolving cutter. The cross feed handle enables the entire table to move across the knee. The knee can be raised or lowered by the knee elevating handle. Few operations carried on this type of machine are: keyways, grooves, gear teeth.

Vertical Milling Machine

In a vertical milling machine the spindle is mounted with its axis perpendicular to the table. The column and the base are formed into an integral casting. The spindle head is fitted vertically in the guide-ways provided in the column. The spindle can be moved up and down over the guideways. A saddle is mounted over the guideways provided on top of the base. The saddle can be moved in the transverse direction. The work table will be mounted over the saddle and can be moved longitudinally. In this machine the workpiece can be moved only in the horizontal plane but not in vertical plane. This machine is suitable for cutting long grooves and slots and also to produce flat faces.

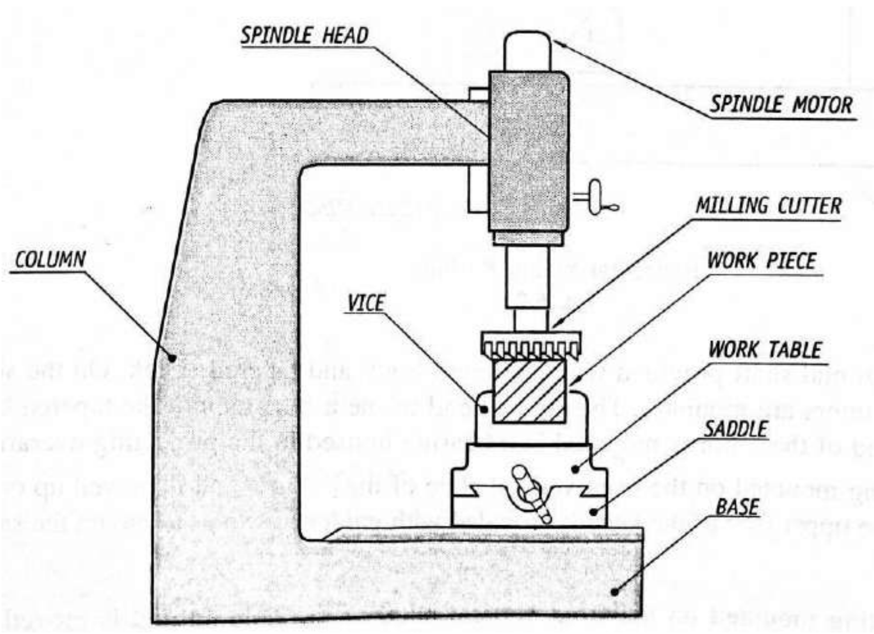


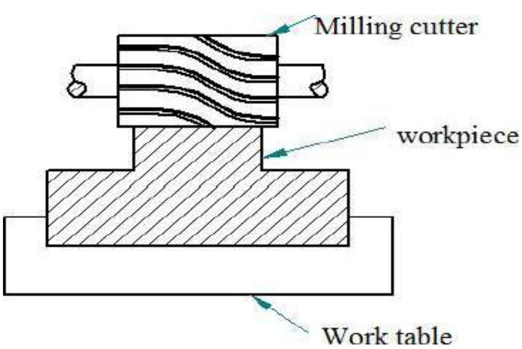
Figure 10: Vertical Milling Machine

Milling Operations

Various milling operations can be performed on a milling machine to produce flat, vertical, inclined surfaces, grooves, slots, keyways, gear teeth etc. Some of the most commonly operations are, plain or slab milling, angular milling, face milling, form milling, slot milling, and straddle milling.

1. Plain or slab Milling:

Plain milling or slab milling is the process employed for machining a flat surface. The workpiece is placed in such a way that the milling cutter axis is parallel to the surface that is being milled. The milling cutter used in this operation is called plain or slab milling cutter. The cutter normally have straight or helical cutting edge on the periphery of the cylindrical surface. The figure 11 shows the plain milling operation carried out on a horizontal milling machine.



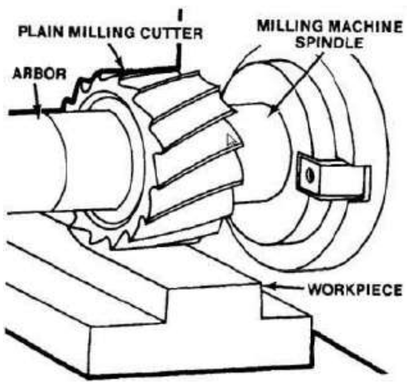
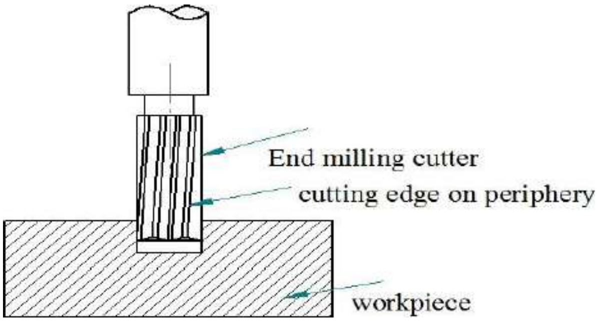


Figure 11: Plain milling operation

2. End Milling

End milling is a process of milling that is used to mill slots, pockets, keyways in such a way that the axis of milling cutter is perpendicular to the surface of the workpiece. A typical end milling operation is shown in figure 12. The end mill cutters have the teeth on the periphery and end, which is integral with the shank for holding and driving the cutter.



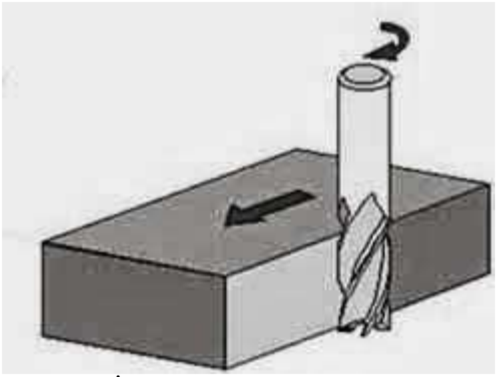
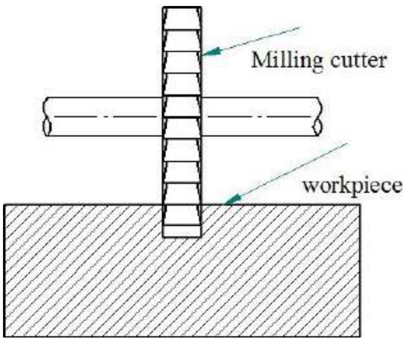


Fig 12: End milling operation

3. Slot Milling

Slot milling is the process of milling slots using a different type of cutter called slot drill which has the capacity to cut into solid materials. Slot drill has the capacity to cut into solid material as shown in figure 13. In slot milling the axis of spindle is parallel to surface of the workpiece. Slot milling cutter has more no. of teeth on its periphery compared to end milling cutter. Hence the milling of slots can be done easily using slot milling compared to end milling. It is generally used to produce rectangular slots, T slots and dovetail slots.



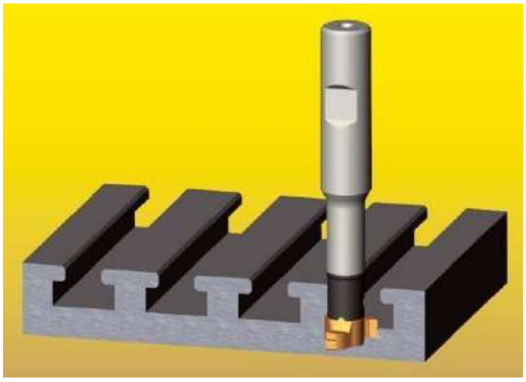
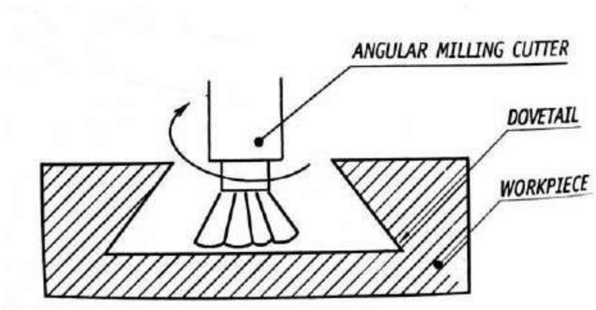


Fig 13: Slot milling operation

4. Angular milling



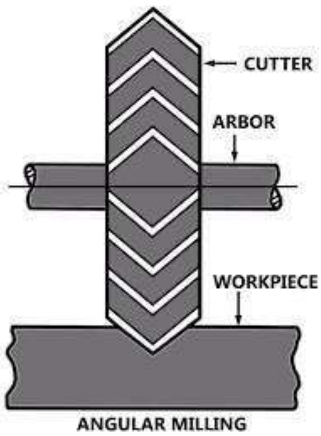


Figure 14: Angular milling

Angular milling is the milling operation used to mill the flat surfaces that are neither parallel nor perpendicular to the milling cutter axis. Angular surfaces like dovetail grooves, chamfers and serrations are done through this operation. Milling of dovetail is shown in figure 14. During the operation the workpiece is held in a wise (which is stationary) and the angular milling cutter is made to rotate at certain speed. The table is moved against the rotating cutter which will remove the material from the workpiece in the form of chip and the required surface is obtained.

5. Form milling

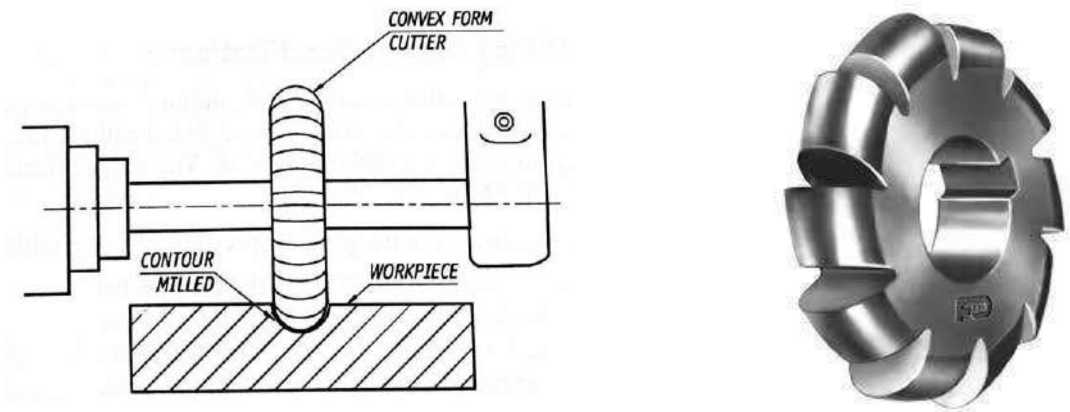


Figure 14: Form milling and form milling cutter

Form milling is a milling process used to machine special forms or contours consisting of curves or straight lines by using a special cutter called *form mill cutter.* The form milling cutter is shaped exactly to the contour that is to be milled. A typical form milling operation and the form milling cutter is shown in the figure 14. During operation the workpiece is held stationary and is moved against a rotating cutter, which will remove the material to form the contours or any required surfaces.

6. Straddle milling

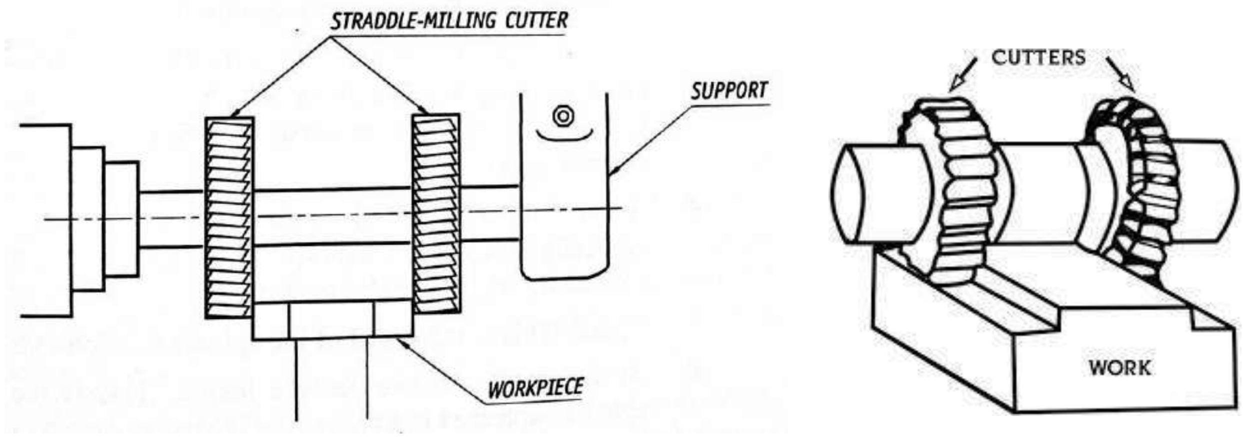


Figure 15: Straddle milling

Straddle milling is a milling operation that is used to machine two or more parallel vertical surfaces at a single time. In straddle milling two side cutters are used simultaneously to produce two parallel surfaces of workpiece. Two milling cutters are mounted on the arbor and the cutters are separated by spacers as shown in the figure 15. High degree of accuracy is obtained by milling two surfaces simultaneously. A typical straddle milling operation used to mill sides of a hexagon is shown in one of the figure 15.

7. Gang milling

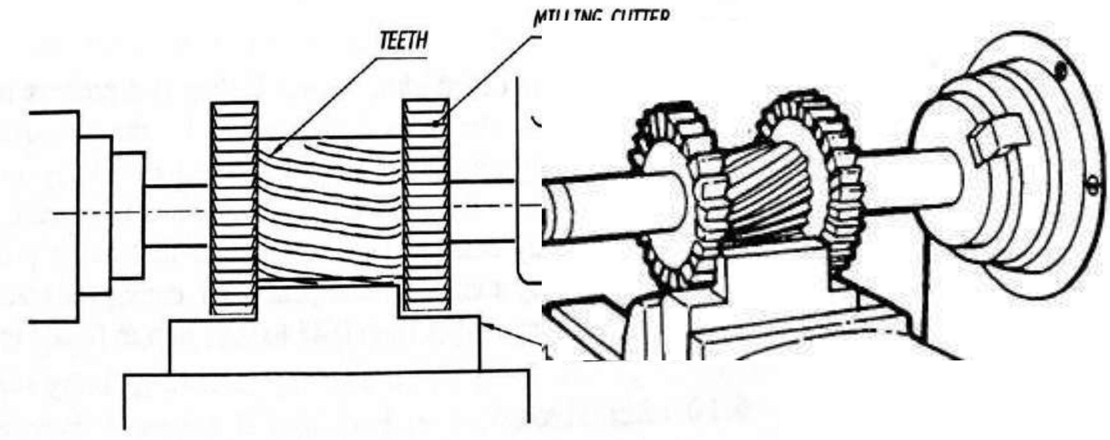


Figure 16: Gang milling

Gang milling is the process of milling several surfaces simultaneously. In this operation more than two milling cutters are used. All the cutters may be mounted on the same arbor as shown in figure
16 and three surfaces are milled simultaneously. The process of milling is similar to straddle milling but the machining is done with several types of milling cutters according to the shape of the desired work surface. A typical gang milling operation is shown in figure 16.

CNC & ROBOTICS

Computer Numerical Control (CNC) is an advanced form of the NC System where the machine control unit is a dedicated microcomputer instead of hard-wired controller, as in conventional NC.

Basic components of a CNC system

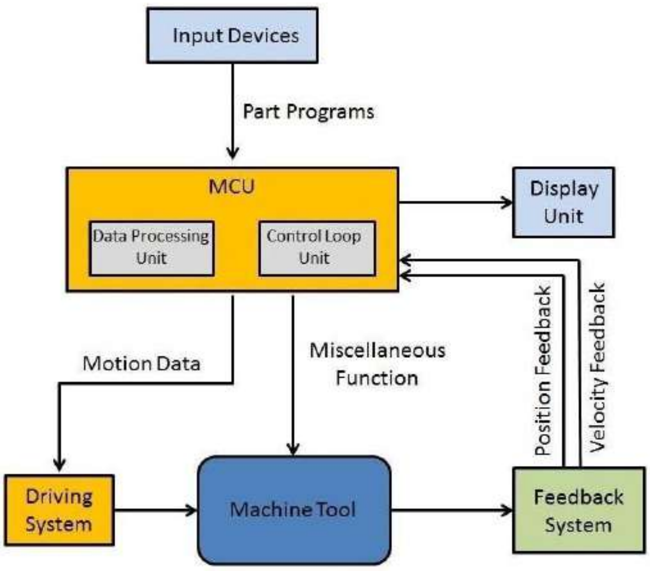


Figure 1 : Basic components of CNC system

The **MCU** is the hardware that distinguishes CNC from conventional NC. The general configuration of the MCU in a CNC system is illustrated in Figure. The MCU consists of following components and sub systems: (1) central processing unit, (2) memory (3) I/O interface, (4) controls for machine tool axes and spindle speed, and (5) sequence controls for other machine tool functions.

Central processing unit. The central processing unit (CPU) is the brain of the MCU. It manages the other components in the MCU based on software contained in main memory. The CPU can be divided into three sections: (1) control section, (2) arithmetic-logic unit, and (3) intermediate access memory.

Memory. The immediate access memory in the CPU is not intended for storing CNC software. A much greater storage capacity is required for the various programs and data needed to operate the CNC system.

Input/output interface. The I/O interface provides communication between the various components of the CNC system, other computer systems, and the machine operator. As its name suggests, the I/O interface transmits and receives data and signals to and from external devices.

Controls for machine tool axes and spindle speed. These are hardware components that control the position and velocity (feed rate) of each machine axis as well as the rotational speed of the machine tool spindle.

Sequence controls for other machine tool functions. In addition to control of table position, feed rate, and spindle speed, several additional functions are accomplished under part program control. These auxiliary functions are generally on/off actuations, interlocks, and discrete numerical data. To avoid overloading of CPU, a programmable logic controller is sometimes used to manage the I/O interface for these auxiliary functions.

Open loop system

Open-loop system**,** also referred to as non-feedback system, is a type of continuous control system in which the output has no influence or effect on the control action of the input signal. In other words, in an open-loop control system the output is neither measured nor "fed back" for comparison with the input. Therefore, an open-loop system is expected to faithfully follow its input command or set point regardless of the final result. Also, an open-loop system has no knowledge of the output condition so cannot self-correct any errors it could make when the preset value drifts, even if this results in large deviations from the preset value.

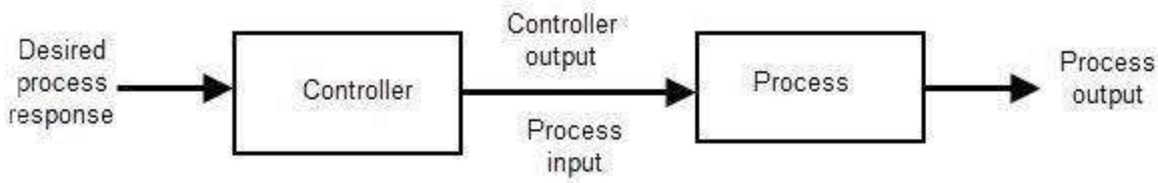


Figure 2: Open loop system

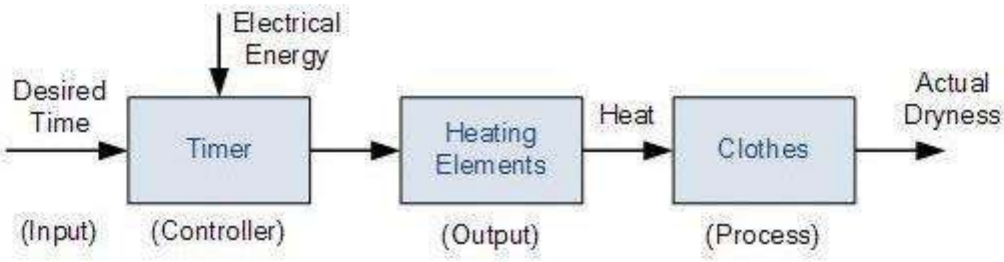


Figure 3: Example for open loop system (drying of clothes)

One of the disadvantages of open-loop systems is that they are poorly equipped to handle disturbances or changes in the conditions which may reduce its ability to complete the desired task. For example, the dryer door opens and heat is lost. The timing controller continues regardless for the full 30 minutes but the clothes are not heated or dried at the end of the drying process. This is because there is no information fed back to maintain a constant temperature.

Closed loop control system

Control system in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called closed loop control system. Open loop control system can be converted in to closed loop control system by providing a feedback. This feedback automatically makes the suitable changes in the output due to external disturbance. In this way closed loop control system is called automatic control system. Figure below shows the block diagram of closed loop control system in which feedback is taken from output and fed in to input.

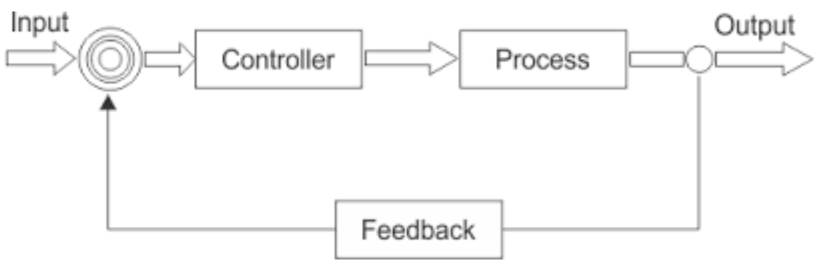


Figure 4: Closed loop system

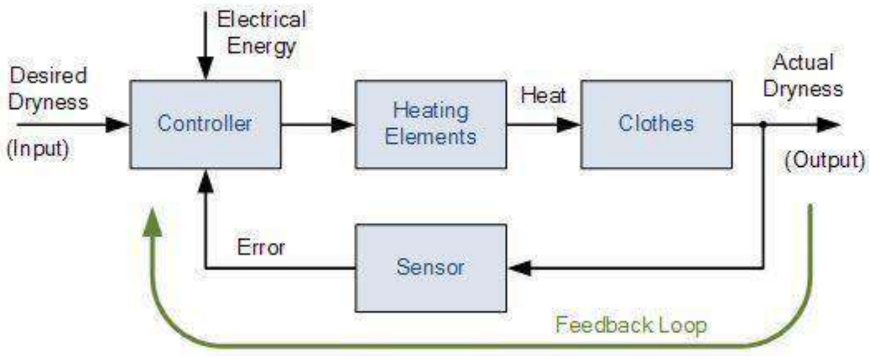


Figure 5: Example for closed loop system (drying of clothes)

So for example, consider electric clothes dryer. Suppose we used a sensor or transducer (input device) to continually monitor the temperature or dryness of the clothes and feed a signal relating to the dryness back to the controller as shown in figure 5. This sensor would monitor the actual dryness of the clothes and compare it with (or subtract it from) the input reference. The error signal (error = required dryness
– actual dryness) is amplified by the controller, and the controller output makes the necessary correction to the heating system to reduce any error.

The major advantages of CNC

1. Increased productivity
2. High accuracy and repeatability
3. Reduced production costs

The major disadvantages of CNC

1.High initial investment

2.High maintenance

3.For low production it is costlier process

4. Reduced indirect operation costs
5. Facilitation of complex machining operations
6. Greater flexibility
7. Improved production planning and control
8. Lower operator skill requirement
9. Facilitation of flexible automation

Machining centres and Turning centres

The term **"machining center"** describes almost any CNC milling and drilling machine that includes an automatic tool changer and a table that clamps the workpiece in place. On a machining center, the tool rotates, but the work does not. The orientation of the spindle is the most fundamental defining characteristic of a machining center. Vertical machining centers generally favor precision while horizontal machining centers generally favor production.

A **turning center** is a lathe with a computer numerical control attachment. Sophisticated turning centers can also perform a variety of milling and drilling operations. Some of the advantages includes High-torque, high-speed turning and milling spindles provide fast, accurate and aggressive metal removal capabilities. Other features includes User-friendly, high functionality CNC controls simplify programming and increase productivity.

INTRODUCTION TO ROBOTICS

DEFINITION

An industrial robot is a programmable, multi-functional manipulator designed to move materials, parts, tools, or special devices through variable programmed motions for the performance of a variety of tasks.

A robot system consists of the following elements.

Manipulator

This is the main body of the Robot and consists of links, joints and structural elements of the Robot.

End Effectors / Gripper

This is the part that generally handles objects, makes connection to other machines, or performs the required tasks.

Actuators

Actuators are the muscles of the manipulators. Common types of actuators are servomotors, stepper motors, Pneumatic / Hydraulic cylinders etc.

Sensors

Sensors are used to collect information about the internal state of the robot or to communicate with the outside environment. Robots are often equipped with external sensory devices such as a vision system, touch and tactile sensors etc which help to communicate with the environment.

Controller

The controller receives data from the computer, controls the motions of the actuator and coordinates these motions with the sensory feedback information.

APPLICATIONS

- Welding
- Painting
- Surface finishing
- Aerospace and automotive industries
- Light assembly such as in the micro-electronics, or consumer products.
- Inspection of parts
- Underwater and space exploration
- Hazardous waste handling

Industrial robots do tasks that are hazardous or tedious.

Exploratory robots explore environments that are inhospitable to humans such as space, military targets or areas of search and rescue operations.

Assistive robots help handicapped individuals by assisting with daily tasks including wheelchair navigation and feeding.

INDUSTRIAL APPLICATIONS

- Material handling
- Material transfer
- Machine loading and/or unloading
- Spot welding
- Continuous arc welding
- Spray coating
- Assembly
- Inspection

ROBOT CONFIGURATIONS

Industrial robots come in a variety of shapes and sizes. They are capable of various arm manipulations and they possess different motion systems.

Four basic configurations are identified with most of the commercially available industrial robots

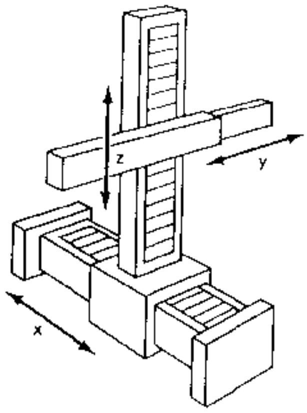
– **Cartesian Coordinate configuration**

– **Cylindrical Coordinate configuration**

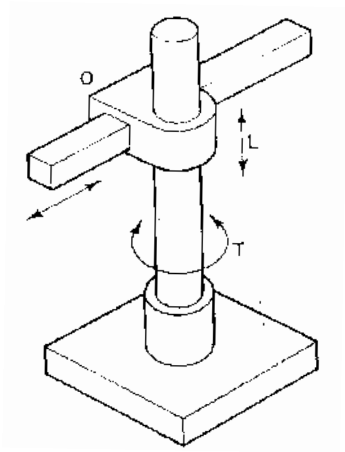
– **Polar Coordinate configuration (Spherical)**

– **Articulated /Jointed-arm configuration (Revolute)**

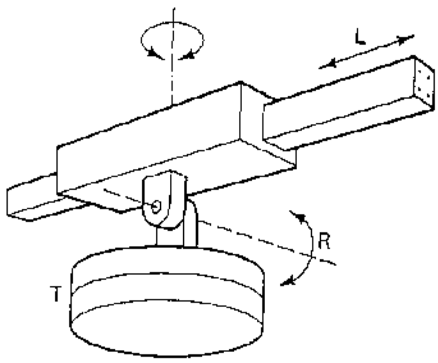
CARTESIAN CONFIGURATION
A robot which is constructed around this configuration consists of three orthogonal slides. The three slides are parallel to the x, y, and z axes of the Cartesian coordinate system. By appropriate movements of these slides, the robot is capable of moving its arm at any point within its three dimensional rectangular spaced work space.



CYLINDRICAL CONFIGURATION
In this configuration, the robot body is a vertical column that swivels about a vertical axis. The arm consists of several orthogonal slides which allow the arm to be moved up or down and in and out with respect to the body. This is illustrated schematically in figure.

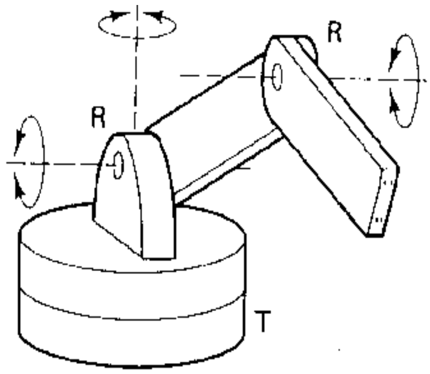


POLAR CONFIGURATION
This configuration also goes by the name “spherical coordinate” because the workspace within which it can move its arm is a partial sphere. The robot has a rotary base and a pivot that can be used to raise and lower a telescoping arm.



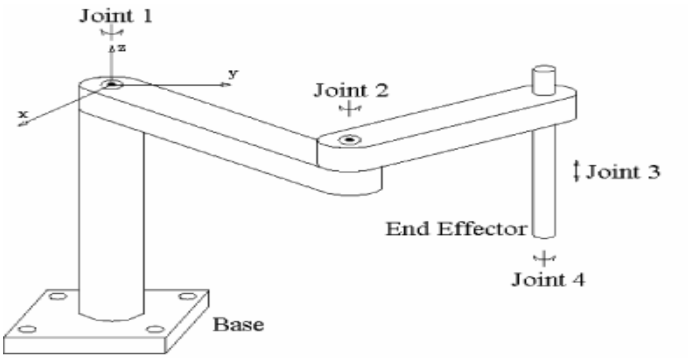
ARTICULATED CONFIGURATION

This is a combination of cylindrical and polar configurations. This is similar in appearance to the human arm. The arm consists of several straight members connected by joints which are analogous to the human shoulder, elbow, and wrist. The robot arm is mounted to a base which can be rotated to provide the robot with the capacity to work within a quasi-spherical space.



Scara Configuration Robot

Its full form is „Selective Compliance Assembly Robot Arm'. It is similar in construction to the jointer- arm robot, except the shoulder and elbow rotational axes are vertical. It means that the arm is very rigid in the vertical direction, but compliant in the horizontal direction. SCARA robots are a popular option for small robotic assembly applications.



Applications: Assembly, Inspection, Machine loading and unloading

ADVANTAGES

1. Robotics and automation can, in many situation, increase productivity, safety, efficiency, quality of the product and consistency of products.
2. Robots can work in hazardous environments.
3. Robots work continuously without any humanity needs and illnesses.
4. Robots have repeatable precision at all times.
5. Greater response time to inputs than humans.
6. Robots can process multiple tasks simultaneously. Humans can process only one.
7. Accident reduction.
8. Greater flexibility, re-programmability, kinematics dexterity
9. Improved product quality
10. Maximize capital intensive equipment in multiple work shifts
11. Reduction of hazardous exposure for human workers
12. Automation less susceptible to work stoppages.

DISADVANTAGES

1. Replacement of human labor results in greater unemployment.
2. Significant retraining costs for both unemployed and users of new technology.
3. Advertised technology does not always disclose some of the hidden disadvantages.
4. Robots are not creative or innovative
5. Robots cannot think independently
6. Robots cannot make complicated decisions
7. Robots cannot learn from mistakes
8. Robots cannot adapt quickly to changes in their surroundings
9. Robots are costly, due to
    - Initial cost of equipment
    - Installation Costs
    - Need for peripherals
    - Need for training

- Need for Programming

10. Robots may have limited capabilities in
    - Degrees of Freedom
    - Dexterity
    - Sensors
    - Real-time Response
11. Robots lack capability to respond in emergencies, this can cause:
    - Inappropriate and wrong responses
    - A lack of decision-making power
    - Damage to the robot and other devices
    - Human injuries

AUTOMATION

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services.

Automation Control System - system that is able to control a process with minimal human assistance or without manual and have the ability to initiate , adjust, action show or measures the variables in the process and stop the process in order to obtain the desired output.

The main objectives of Automation Control System used in the industry are:

1. To increase productivity
2. To improve quality of the product
3. Control production cost

TYPES OF AUTOMATION

1. FIXED AUTOMATION

- ➢ It is a system in which the sequence of processing operations is fixed by the equipment configuration.
- ➢ This control system is designed to perform a specific task.
- ➢ Functions of control circuit are fixed and permanent.
- ➢ It will be complicated if we want to do other task apart from the existing task.

Typical Features of Fixed Automation:

- ➢ High initial investment for custom engineered equipment.
- ➢ High production rates.
- ➢ Relatively inflexible in accommodating product changes.
- ➢ Low cost per piece.
- ➢ Economical only when there is a high demand for products.
- ➢ Large number of equipments can be accommodated thereby reducing unit price of the product.

2. PROGRAMMABLE AUTOMATION

- ➢ It is used when the volume of production is relatively low and varieties of products are to be produced.
- ➢ The production equipment is designed with the capability to change the sequence of operation to accommodate different product configurations.
- ➢ The operations sequence is controlled by program, which is a set of instructions coded so that the system can read and interpret them.
- ➢ New programs can be prepared and entered into the equipment to produce new product.

Typical Features of programmable automation:

- High investment in general purpose equipment.
- Low production rates relative to fixed automation.
- Flexibility to deal with changes in product configuration.
- Most suitable for batch production.
- Wide variety of parts.
- Higher cost per piece.

3. FLEXIBLE AUTOMATION

- It is an extension of programmable automation. A flexible automated system is one that is capable of producing a variety of products with virtually no time lost for changeovers from one product to the next.
- There is no loss in production time while reprogramming the system and altering the physical setup (tooling, fixtures, m/c settings).
- Consequently the system can produce various combinations and schedules of products instead of requiring they be made in separate batches.

Typical Features of flexible automation:

- High investment for a custom engineered system.
- Continuous production of variable mixtures of products.
- Medium production rates.
- Flexibility to deal with product design variations.

APPLICATIONS OF ROBOTS

1. Transfer Materials:

a) Pick and Place application: The objects are picked from one location and placed to another location.

b) Palletizing/depalletizing application: The robot stacks the products on to a pallet during palletizing operation and picks the parts from an orderly stacked pallet to another location during depalletizing operation.

c) Stacking application: The robots are used to stack the parts one upon another.

d) Insertion operation: The robots are used to insert parts into the compartments or space provided in a cartoon.

2. Machine Loading/unloading:

a) Machine loading: In the loading operation the robot is used to load parts into the production machine. Example: Press working process

b) Machine unloading: In the unloading operation the robot is used to unload the finished part that comes out of a production machine. Example: Die casting

3. Processing Operations:

a) Spot Welding: The end effector of the robot is the spot welding gun that applies the approximate pressure and current to the sheet parts to be welded.

b) Arc Welding: The robots are also used in arc welding application where the end effector is

c) replaced with arc welding torch.

d) Spray coating: Spray coating robots are used in coating of the exterior and interior parts of a car, wood furniture etc.

4. Assembly and Inspection:

Assembly automation using robots will ensure higher productivity, consistency in quality and cost savings when compared to manual assembly.

The robot arm manipulates an inspection probe that moves relative to the product to be inspected. The end effector here is the inspection probe. The robots are also used to inspect whether the part is present on an assembly or not, inspect the assembly of the part to an engine etc.

NUMERICAL CONTROL (NC) SYSTEMS

The basic elements of an operational NC system consist of the following three major components.

1. Program of instructions.
2. Machine Control Unit (MCU).
3. Machine tools and tooling.

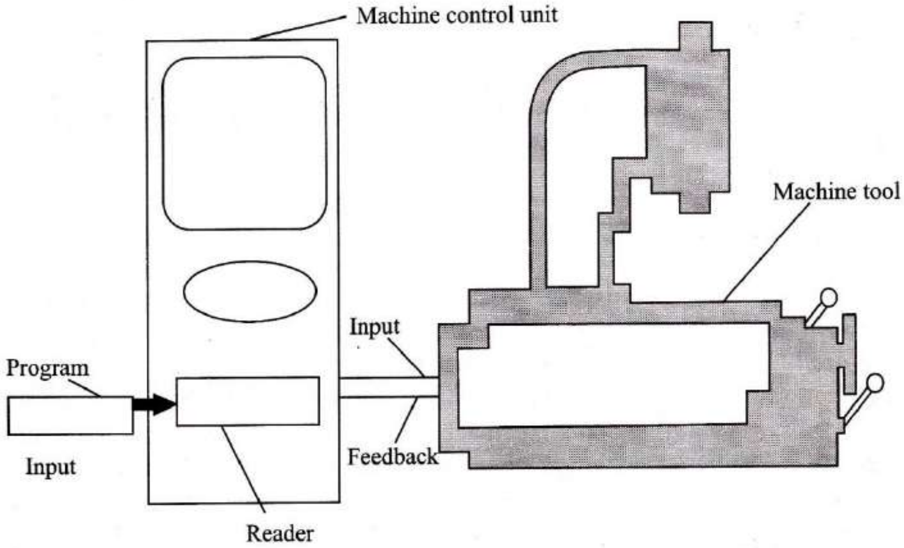


Figure 11.6 Block diagram of NC system.

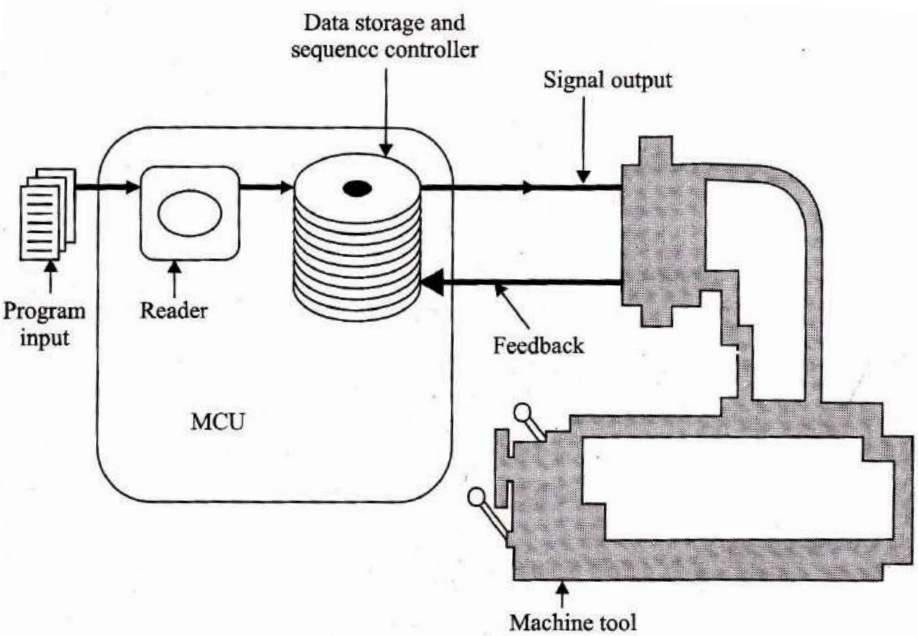


Figure 11.7 Block diagram of MCU.

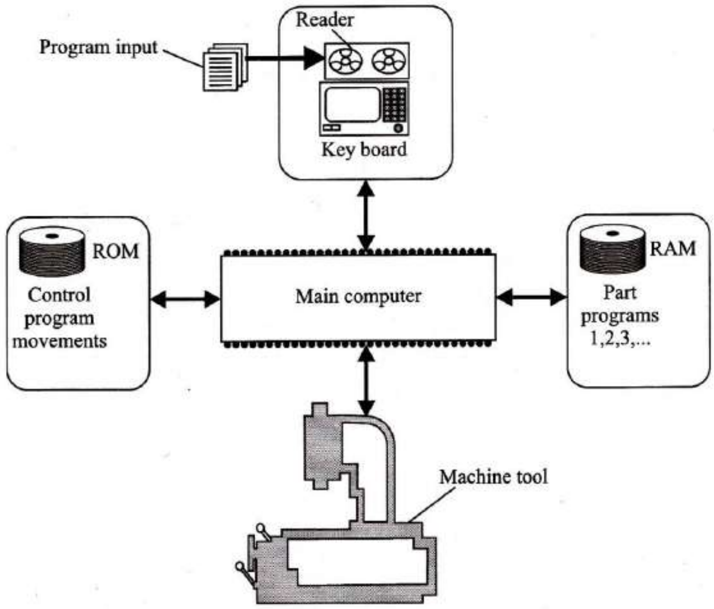


Figure 11.8 Block diagram of CNC.

Steps in NC Manufacturing

Process Planning and Scheduling: Based on the fabrication drawings all the process including the sequence of manufacturing is listed. Based on this, sheet setup is generated.

Part Programming: The sheet setup is used to develop the part program manually or by computer.

Coding of Part Program: The program generated is converted into a machine language program. It is then put on an input media such as CD and then transferred to the MCU memory for used during manufacturing.

Program Verification: The accuracy of the program can be verified by dry run on the machine which traces out the tool profile. It can also be displayed on the screen by simulation of program run. The program is modified if required after the dry run.

NC Machine Operation: The NC machine operator is provided with the setup sheets and tool details from the tool issue room. The machine is then started and the actual machining of the work is done.

COMPUTER NUMERICAL CONTROL (CNC) SYSTEMS

Computer numerical control is basically an NC system which uses a dedicated computer as the control unit. The presence of microprocessors, memory and input output devices have raised the level of automation in NC system.

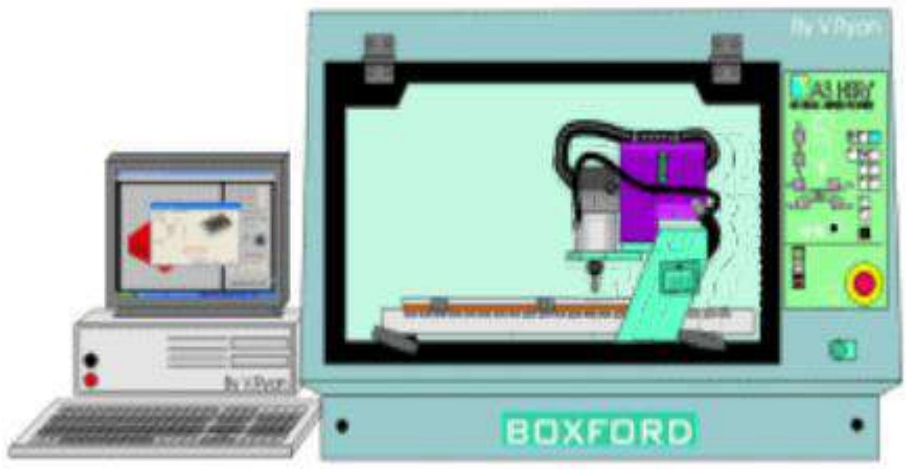
The use of computers adds two important functions in NC system.

1. Program storage capacity
2. Data processing to the NC system

Configuration

The general appearance of NC and CNC machines are similar. In NC system, the machine control unit is executing block by block instructions. In CNC system, the entire program is first fed into the computer memory. The stored program provides the required instructions for execution. This is carried out by generating pulses for each axis movement of the machine tool.

In modern CNC systems, end-to-end component design is highly automated using computer aided design (CAD) and computer aided manufacturing (CAM) programs. The programs produce a computer file that is interpreted to extract the commands needed to operate a particular machine and then loaded into the CNC machines for production. Since any particular component might require the use of a number of different tools – drills, saws, etc., modern machines often combine multiple tools into a single "cell".



COMPUTER NUMERICAL CONTROL - MACHINE

ADVANTAGES

a) CNC machines can be used continuously 24 hours a day. 365 days a year and only need to be switched off for occasional maintenance.
b) CNC machines are programmed with a design which can then be manufactured hundreds or even thousands of times. Each manufactured product will be exactly the same.
c) Less skilled/trained people can operate CNCs unlike manual lathes / milling machines etc., which need skilled engineers.
d) CNC machines can be updated by improving the software used to drive the machines
e) Training in the use of CNCs is available through the use of virtual software. This is software that allows the operator to practice using the CNC machine on the screen of a computer. The software is similar to a computer game.
f) CNC machines can be programmed by advanced design software such as Pro/DESKTOP, enabling the manufacture of products that cannot be made by manual machines, even those used by skilled designers / engineers.
g) Modern design software allows the designer to simulate the manufacture of his/her idea. There is no need to make a prototype or a model. This saves time and money.
h) One person can supervise many CNC machines as once they are programmed they can usually be left to work by themselves. Sometimes only the cutting tools need replacing occasionally.

DISADVANTAGES

a) CNC machines are more expensive than manually operated machines, although costs are slowly coming down
b) The CNC machine operator only needs basic training and skills, enough to supervise several machines. In years gone by, engineers needed years of training to operate centre lathes, milling machines and other manually operated machines. This means many of the old skills are been lost.
c) Less workers are required to operate CNC machines compared to manually operated machines. Investment in CNC machines can lead to unemployment.
d) Many countries no longer teach pupils 1 student how to use manually operated lathes / milling machines etc... Pupils / students no longer develop the detailed skills required by engineers of the past. These include mathematical and engineering skills.