

# CNC MACHINES AND AUTOMATION



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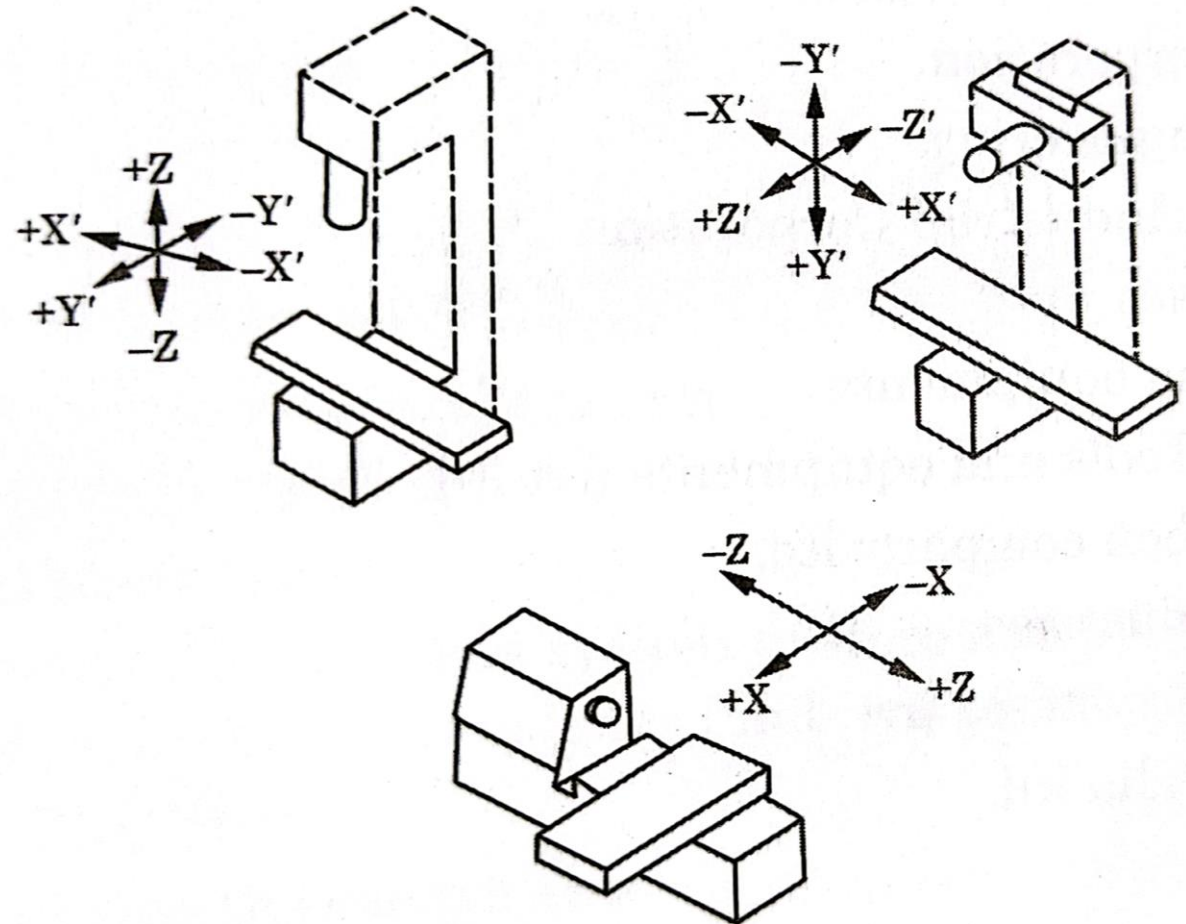
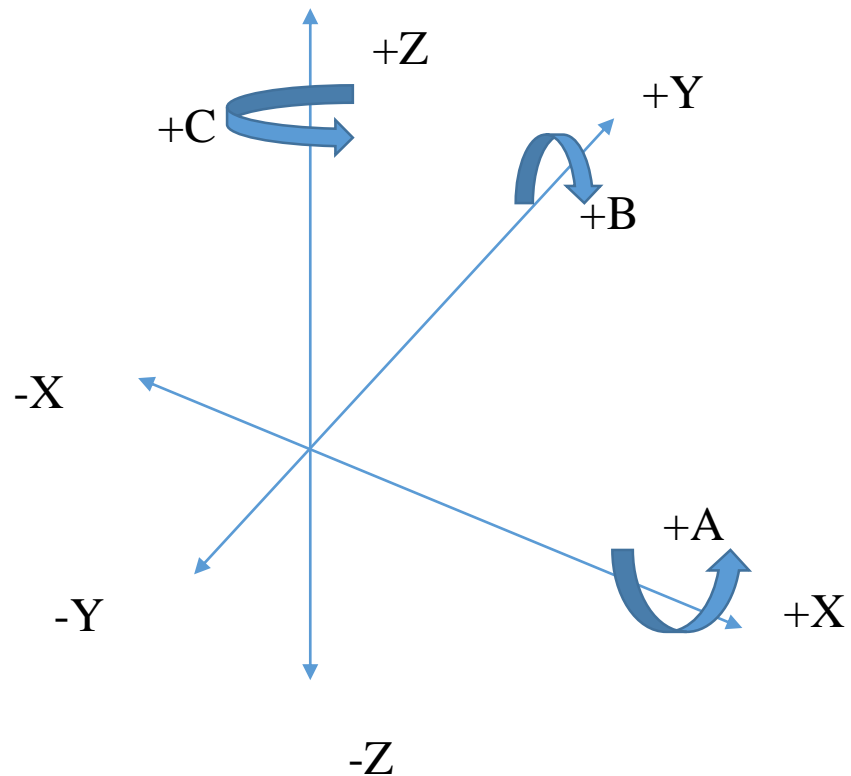
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# Axis Identification

Most of machines have two or more slideways disposed at right angle to each other, along which slides are displaced.





# Chapter 2

## (Construction and Tooling)

# Design Features

CNC machines need special design for its elements as these are high accuracy and productivity machines.

- Understand the development in design and construction of machine structure.
- Different type of elements of motion transmission.
- Contribution of slideways.
- Tool and work devices
- Swarf Removal.
- Feedback mechanism.
- Various types of drives

**Machine Structure:** - It should be able to meet the following main objectives:

- i) High Precision and accuracy
- ii) Reliability and repeatability
- iii) Efficiency and performance

The basic design factors involved in the design of machine structure follows:

1. Static load
2. Dynamic load
3. Thermal load
4. Guideways
5. Feed Drive:
  - i) Servo Motor
  - ii) Mechanical Transmission system
6. Spindle bearing: i) Hydrodynamic ii) Hydrostatic iii) Antifriction
7. Measuring systems: i) Direct ii) Indirect
8. Controls, software and user interface
9. Gauging
10. Tool monitoring systems

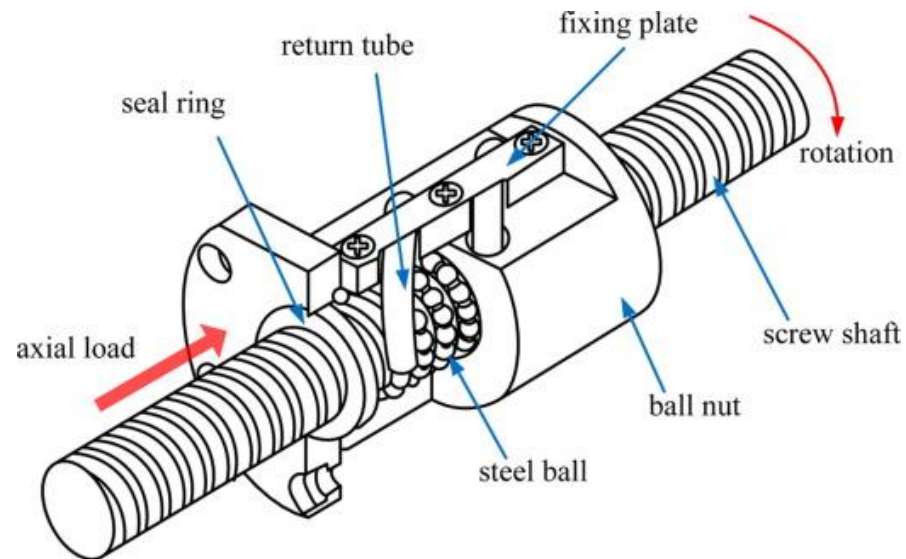
**Elements of Motion Transmission:** - The old conventional machines use lead screw for the motion transmission. For CNC machines it is not suitable.

- High friction between lead screw and nut
- Poor power transmission efficiency
- Inaccuracy due to backlash

Alternative is recirculating ball screw and nut arrangement.

**Advantages:**

1. High efficiency: - Upto 90%
2. Reversibility: - Possible to back drive.
3. Wear and life
4. No stick slip



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**Slideways:** - The old conventional machines has direct metal to metal contact between the slideways and the moving slides. But the design of slideways of CNC machine tool should have :

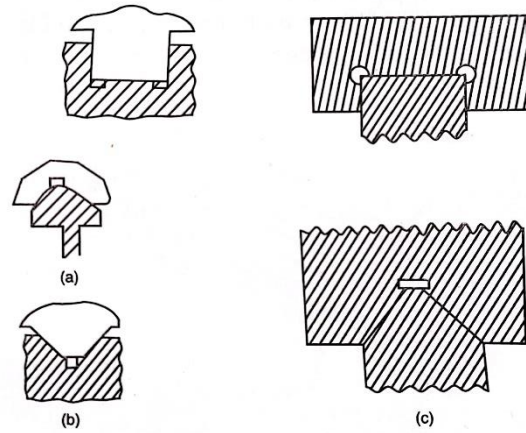
- i) Reduce friction
- ii) Reduce wear
- iii) Smoothness of the drive.

Type of Slide Ways

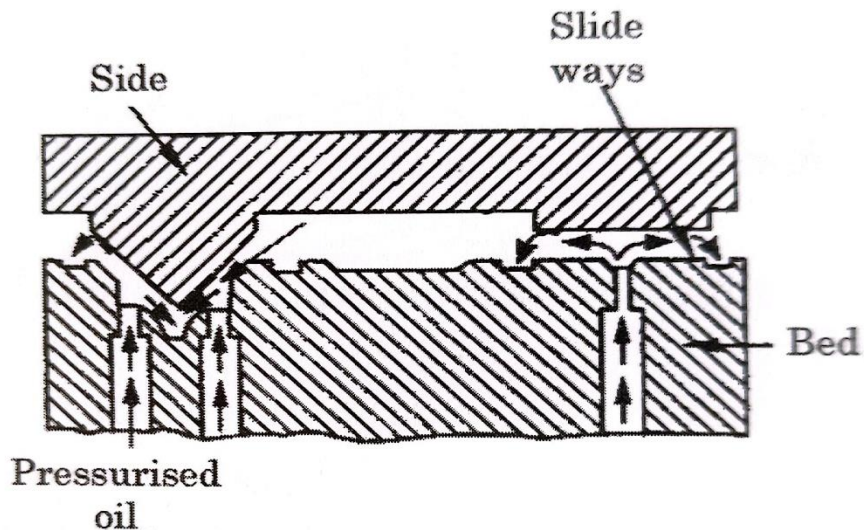
- i) Plain slide ways
- ii) Anti-friction slide ways
  - a) Ball type
  - b) Roller type
- iii) Pressurized slide ways
- iv) Coating type slideways



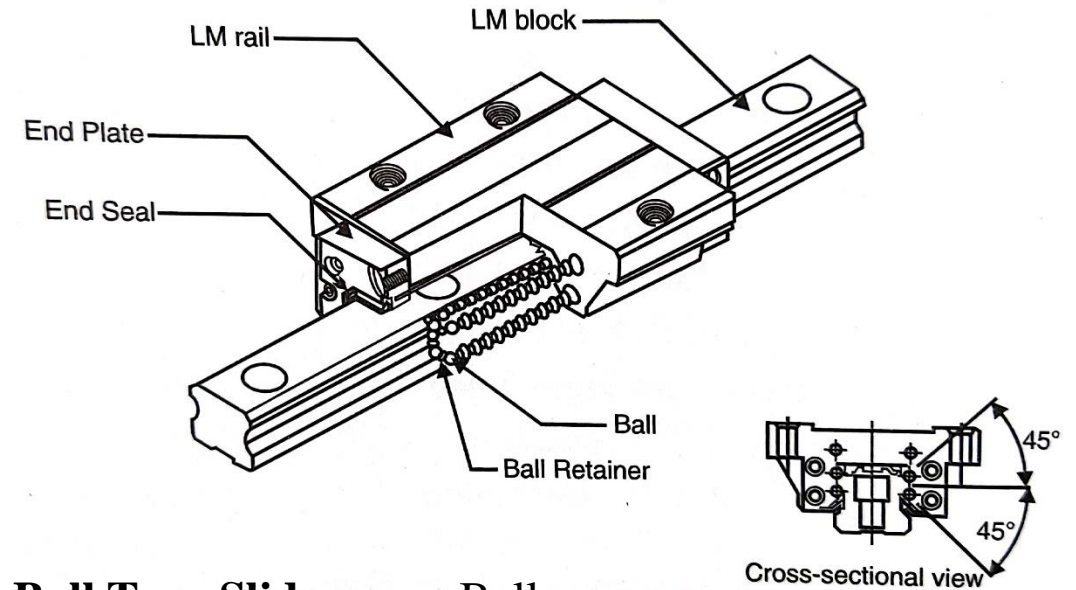
**Plain slide ways:** - These are also known as friction slide ways. They have good damping characteristics than anti-friction and pressurized slide ways.



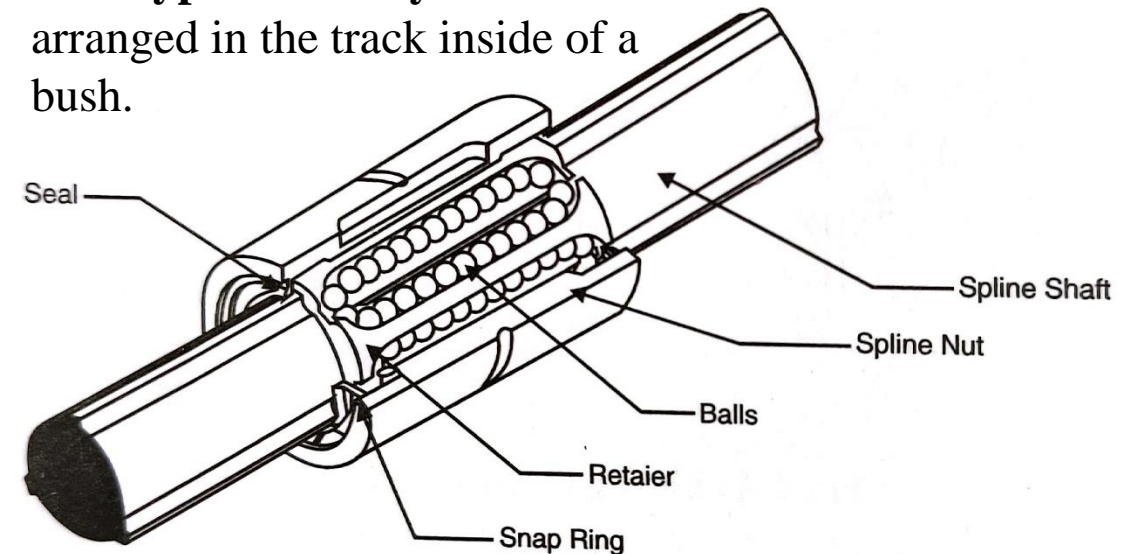
**Pressurized Slide Ways:** - In these slide ways air or oil is pumped between slide guide and bed at high pressure so that metal to metal contact will be less.



**Anti-friction Slides:** - These are also known as friction slide ways. They have good damping characteristics than anti-friction and pressurized slide ways.



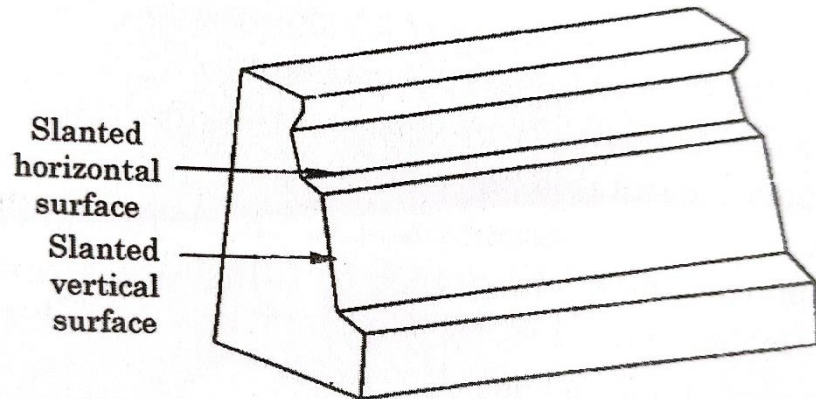
**Ball Type Slide ways:** Balls are arranged in the track inside of a bush.



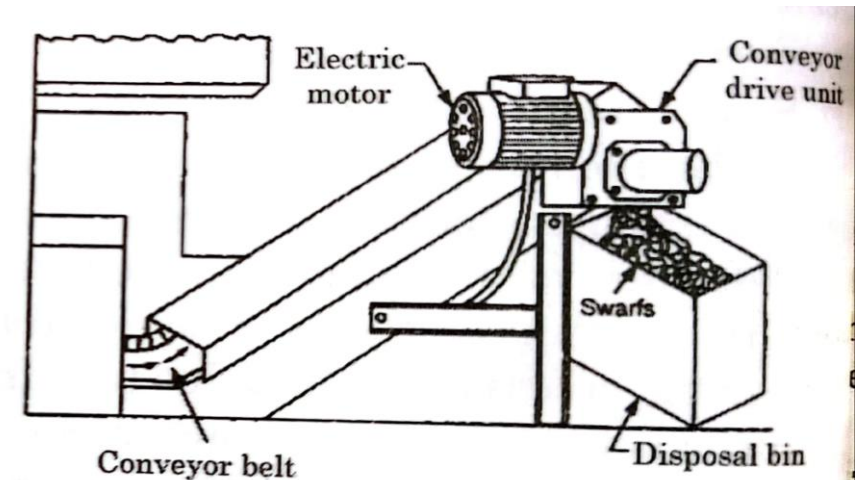
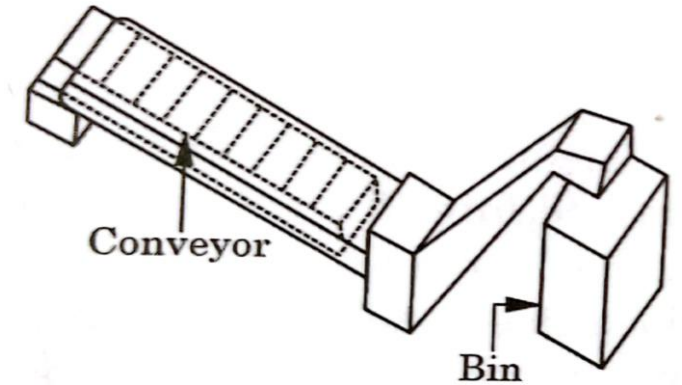


**Swarf Removal:** -CNC machines are designed to work at optimum cutting condition with the improved cutting tools on a continuous operation basis. Since the cutting time is much more in CNC machines, the volume of swarf generated is also more.

**Swarf removal from cutting zone:** - It is generally taken care of by the design configuration of the machine. Slant bed and vertical bed turning centers have the advantages over flat bed or horizontal configuration in that the swarf does not accumulate on the guide ways. Some time coolant wash is embedded in part programme.



**Swarf disposal from machine tool:** - Continuously operating linear or rotary conveyors are used for removing the swarf from machine tool. The system is such that the swarf from the cutting zone falls directly on the conveyer and immediately taken away.



**Location of transducers/Control Elements:** The control unit should be situated so that it is convenient for the operator to operate the machine from control place. The control unit should offer the facilities such as:

1. Indicate the current status and position of various machine tool feature and give feed back.
2. Allow manual or semi-manual control of machine tool elements.
3. Enable machine tool to be programmed.

The position of slides can be monitored with the help of linear and rotary transducers.

**Safety and Guarding:** Since the CNC machine are under continuous automatic operation, there is a need to protect the machine guideways and to ensure the safety of the operator.

a) Protection of guideways

- i) Overload protection
- ii) Clamping sensors
- iii) Work-table control sensors
- iv) Measuring device safeguards

b) Safety of operator

- i) Perimeter guards
- ii) Pressure mats
- iii) Light barriers
- iv) Safety clutches

**Feedback Mechanism in CNC Machines:** In CNC machine tools that operators on closed loop system a feedback device is provided to accurate control the movement of the axes. To perform the above task a feedback device is needed.

The most commonly used feedback devices are:

- i) Optical Encoders: - These can be of two types, Absolute and Incremental.
- ii) Resolver
- iii) Inductosyn
- iv) Linear Scales

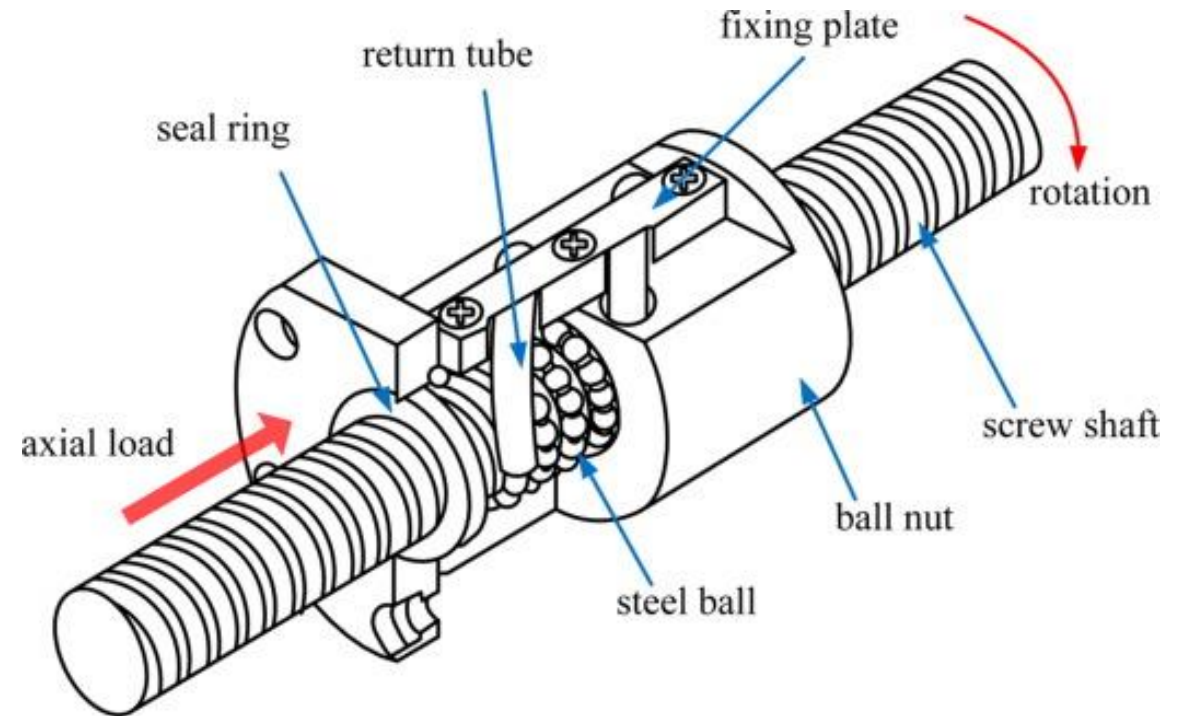
**Drive units: -**

- To drive the spindle
- To drive the axis

**Motor and Leadscrew:** - The leadscrew get the rotary motion from the motor. The work table is mounted on the leadscrew. Both motor and leadscrew are the main parts of the NC positioning system.

**Ball Screw and Nut Assembly:** - Ball screws are employed in feed mechanism of CNC machine tool. These have many advantage over conventional lead screw as given:

- Low coefficient of friction
- Longer life
- Wear of screw is relatively small hence good accuracy
- Less power required to drive
- By preloading the assembly, clearance and backlash can be eliminated
- High transmission efficiency



Recirculating ball screw and nut arrangement



## Specifications of a CNC system

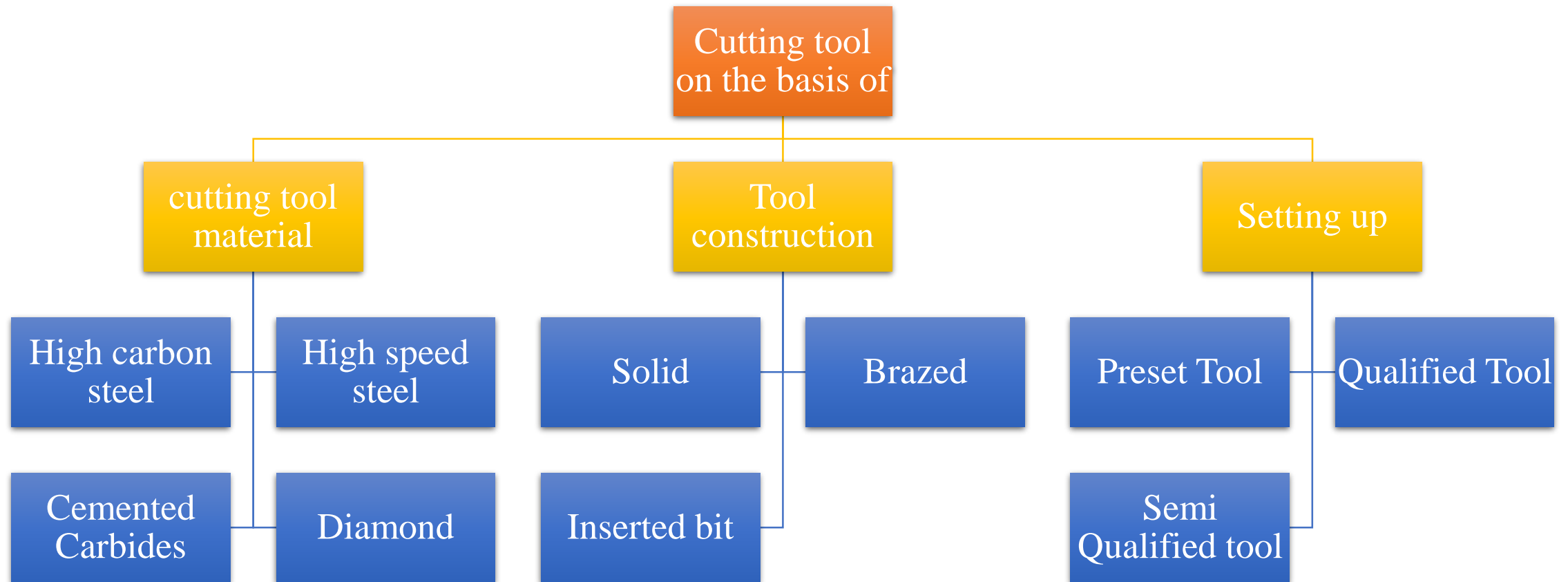
1. Number of controlled axis	: Two/Four/Eight etc.	10. Compensations	: Backlash
2. Interpolation	: Linear/circular/parabolic or cubic/cylindrical		: Lead screw with pitch error
3. Resolution	: Input resolution (feedback) : Programming resolution		: Temperature : Cutter radius compensation
4. Feed rate	: Feed/Min : Feed/revolution	11. Programmable logic controller	: Built in /External : Type of communication with NC
5. Rapid traverse rate	: Feed rate override : Feed/Min		: Number of inputs, outputs, timers, counters
6. Operating modes (editing)/Input/Output/Machine data set-up/Incremental etc.	: Manual/Automatic/MDI		: User memory : Program organisation
7. Type of feedback	: Digital (rotary encoders with train of pulsed) : Analog (transducers etc.) : Both	12. Thread cutting/Tapping	: Type of threads that can be cut
8. Part program handling	: Number of character which can be stored : Part program input devices : Output Devices	13. Spindle control	: Analog/Digital control : Spindle orientation : Spindle speed overrides
9. Part programming	: Though MDI : Graphic simulation : Blue print programming : Background editing	14. Other features	: Inch/Metric switch over : Polar coordinate inputs : Programming resolution

## Safety provision of CNC machine

- i) Most of CNC machine will not start unless the safety guard is in position.
- ii) It is essential that trainer/students operators receive all necessary instruction before use any CNC machine/equipment.
- iii) Most of CNC machine work behind a guard that is closed, transparent safety door.
- iv) In some CNC machine pressure mats are used to avoid accident.

# Various cutting tool for CNC machines

The cutting tool can be divided into following type on the basis of cutting material, tool construction and setting up of tools.



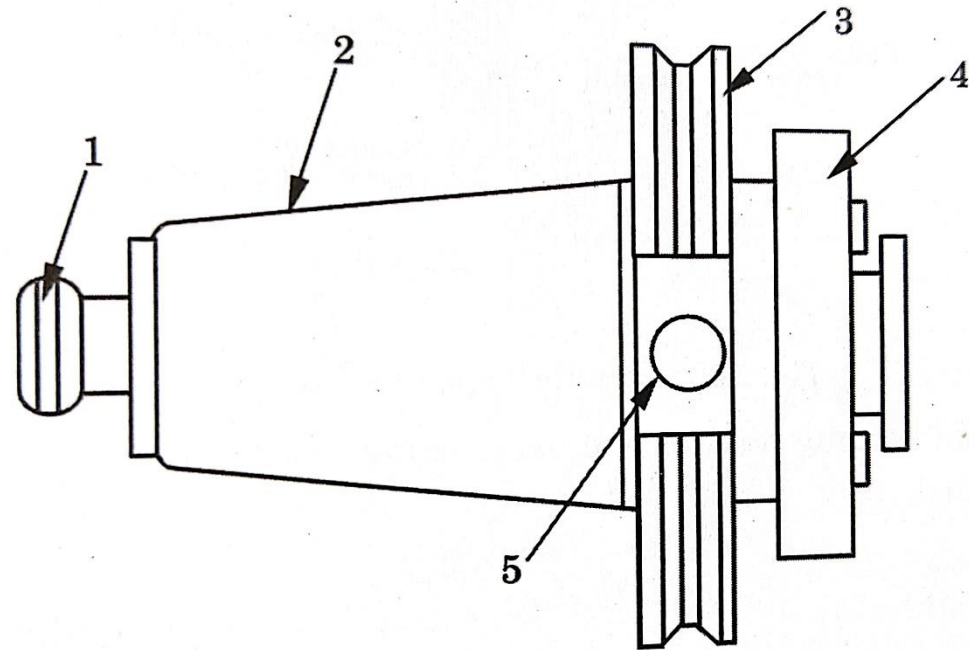
# Properties of Tool Materials

- ❖ Toughness: - It enables the cutting tool to withstand various forces and to absorb shock during interrupted cutting.
- ❖ Hot hardness: - Tool must retain its hardness at high temperature.
- ❖ Wear resistance
- ❖ Thermal conductivity
- ❖ Harden ability
- ❖ Recovery hardness

# Concept of CNC tool holder

A tool holder consists of five basic components

- a) Pull stud
- b) Tapered shank
- c) Flange
- d) Adapter
- e) Oppose slot



# Automatic Tool changer (ATC)

A number of machining operation may be performed for finishing a particular job. So, variety of tools are used to do the machining operations. To reduce idle time and improve the machine utilization, we used a device known as ATC. ATC take approximately 3 to 7 seconds.

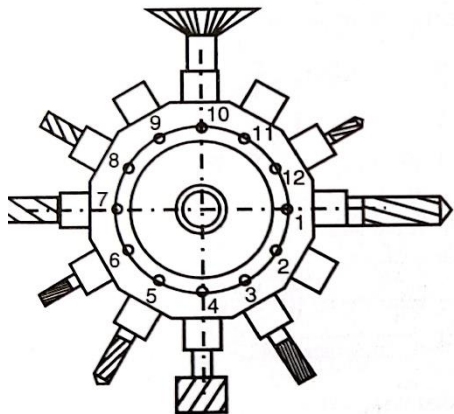
## ATC advantages

- a) Lines changed in second instead of hours.
- b) Increase operator safety by changing tools automatically.
- c) Change tools in seconds for maintenance and repair.
- d) Increase flexibility.
- e) Heavy and large multi-tools that are automatically exchanged.

# Tool Magazine

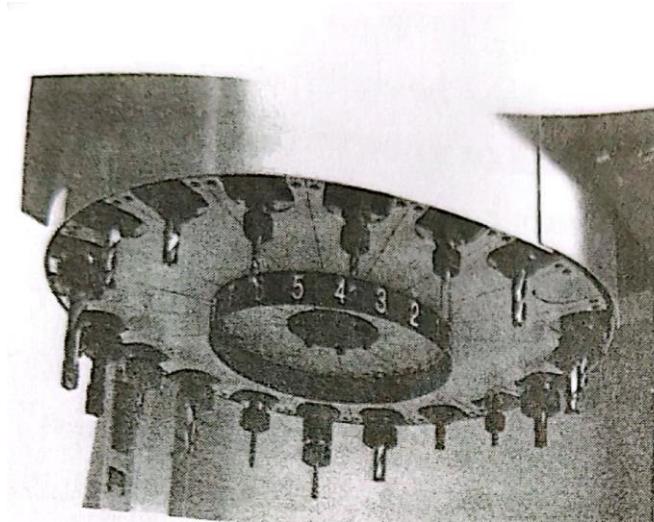
## Turret

- Simplest type



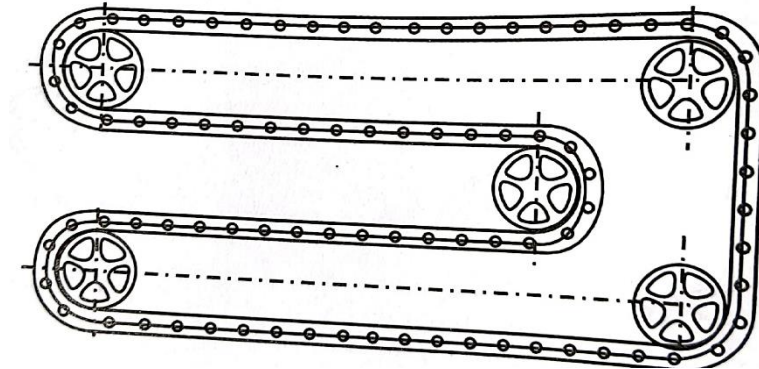
## Drum

- Diameter of tool indicated the number of tool it can hold



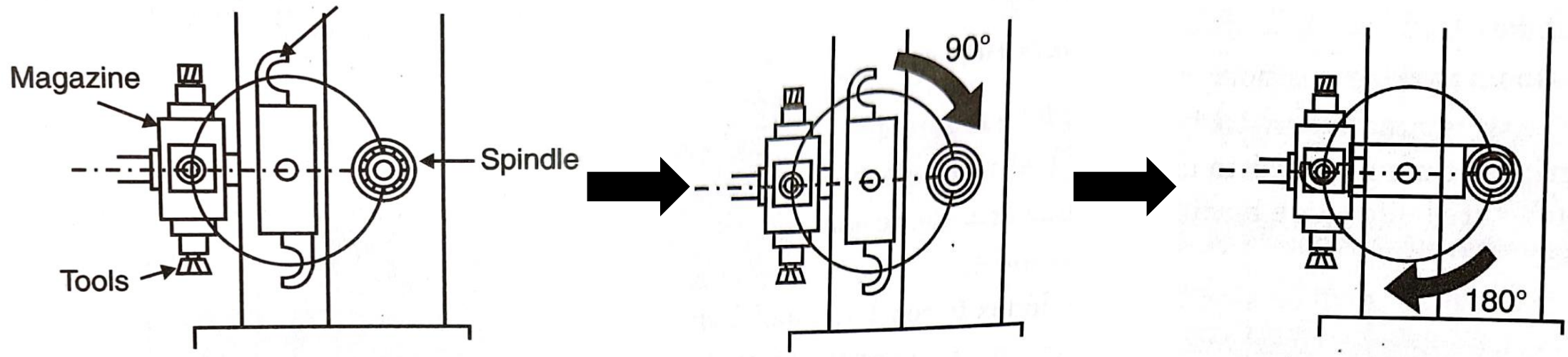
## Chain

- Can carry 30-200 tools
- Tool search time is more

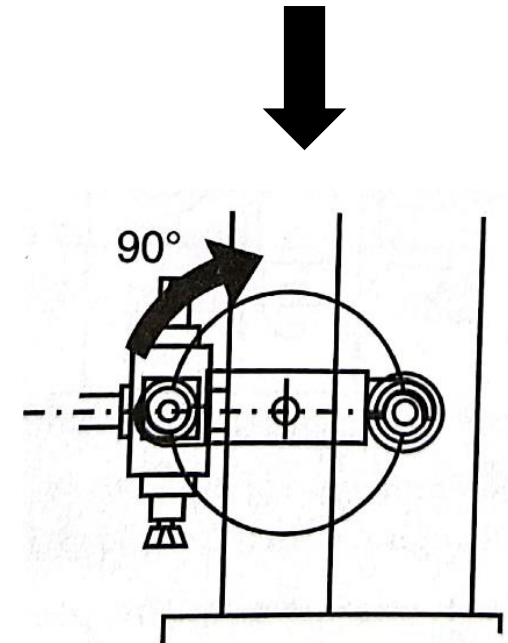




## Tool changing procedure



- Tool magazine to index into the right position where the tool is placed from the spindle.
- Stop the spindle at right orientation.
- Tool change arm to index to reach the tool magazine.
- Tool change arm to pick the tool from magazine and spindle simultaneously.
- Arm to index to reach the spindle.
- New tool is placed in spindle and old one in tool magazine.
- Tool change arm moves into its park position.



# **Management of A Tool Room**

A tool room is a place in the industry where the different type of tools are stored or placed. Here management of a tool room means how they are managed.

Thank You