CNC MACHINES

Machine Control Systems

Machine controls are divided into four groups:

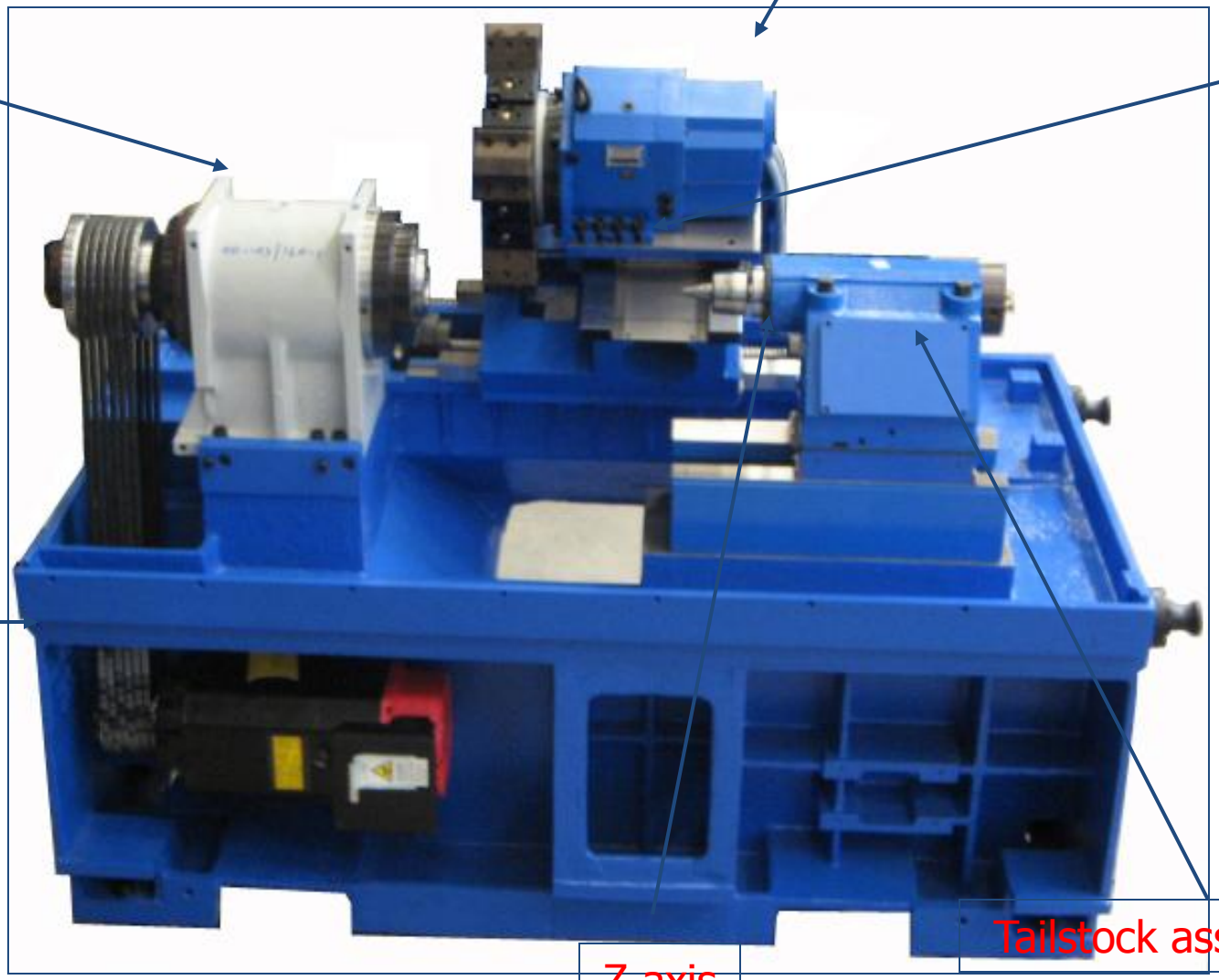
(a) Conventional Machine System (Manual Control)

(b) Traditional Numerical Control (NC)

(c) Computer Numerical Control (CNC)

(d) Distributed Numerical Control (DNC)

Overview of a Basic Machine



(b) NC Machines

- **Numerical control(NC)** refers to the method of controlling the manufacturing operations by means of directly inserted coded numerical instructions into the machine tool.

- Numerical Control is defined as a form of software controlled automation, in which the process is controlled by alphanumeric characters & symbols (i.e. number , letters, and symbols.)

- According to these definitions, a programme is prepared which consists of combination of characters and numbers in sequence describing the **position of the tool and job, the cutting speed and feed.**

- The first NC machine was built in the 1940s and 1950s, based on existing tools that were modified with motors .

- The part program is entered on **the program tape/Magnetic tape** in the form of punched holes.

- Then the tape is inserted to the **Tape Reader** which is the the **Machine Control Unit**.

- An **NC machine is numerically controlled but** has no memory storage and is run off of the “tape” each time the machine cycles.

Punched tape for NC Machine

- **Punched tape** or **perforated paper tape** is a form of data storage, consisting of a long strip of paper in which holes are punched to store data



Fig. Punched Tape



Fig. Paper tape reader

(c) CNC Machines

- CNC refers to a system that has a local computer to store all required numerical data.
- The advantages of CNC systems are to store and execute a number of large programs, to allow editing of programs, to execute cycles of machining commands, etc.

(d) Distributed Numerical Control (DNC)

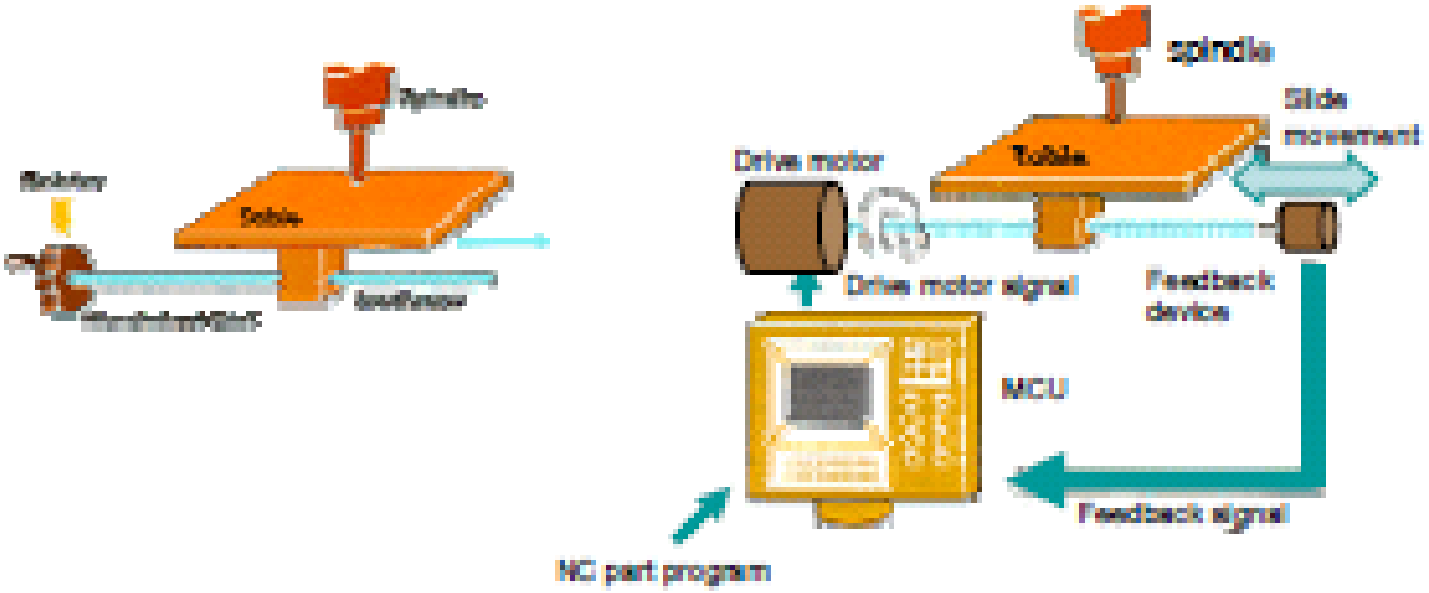
- **Distributed Numerical Control (DNC**) is similar to CNC, except a remote computer is used to control a number of machines.
- An **off-site mainframe host computer** holds programs for all parts to be produced in the DNC facility.
- Programs are downloaded from the **Mainframe Computer,** and then the local controller feeds instructions to the hardwired NC machines.
- The recent developments use a central computer which communicates with local CNC computers **(also called Direct Numerical Control).**

What is CNC?

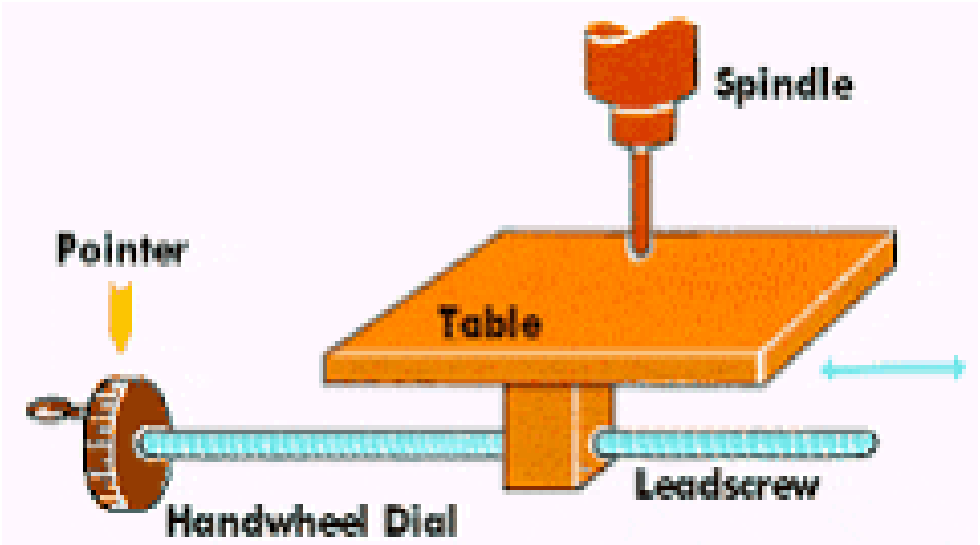
- CNC means Computer Numerical Control.
- A form of programmable automation.
- Typical program containing coded alphanumeric data, such as

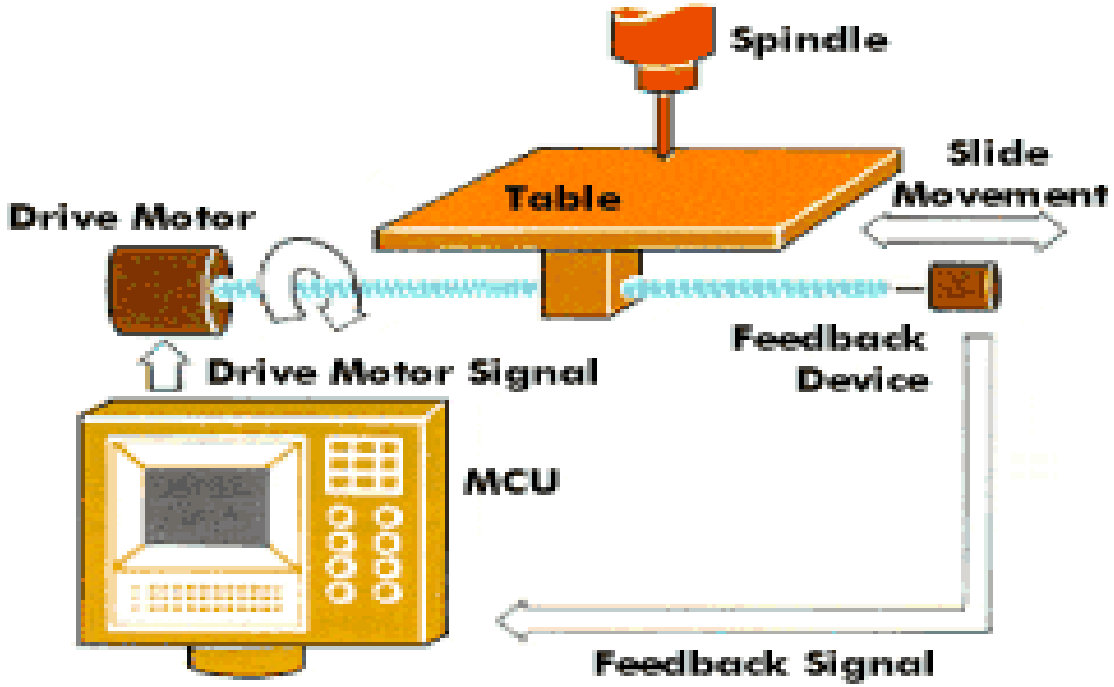
G01 X120 Y200

The data represent relative positions between a cutting tool and a workpiece



Basic Progression to a CNC M/c





Types of CNC Machines

- CNC Turning Centre
- CNC Milling Machine
- CNC Horizontal Machining Centre (HMC)
- CNC Grinder
- CNC Drilling Machine
- CNC Gear Cutting Machine
- CNC Turret Punch Press

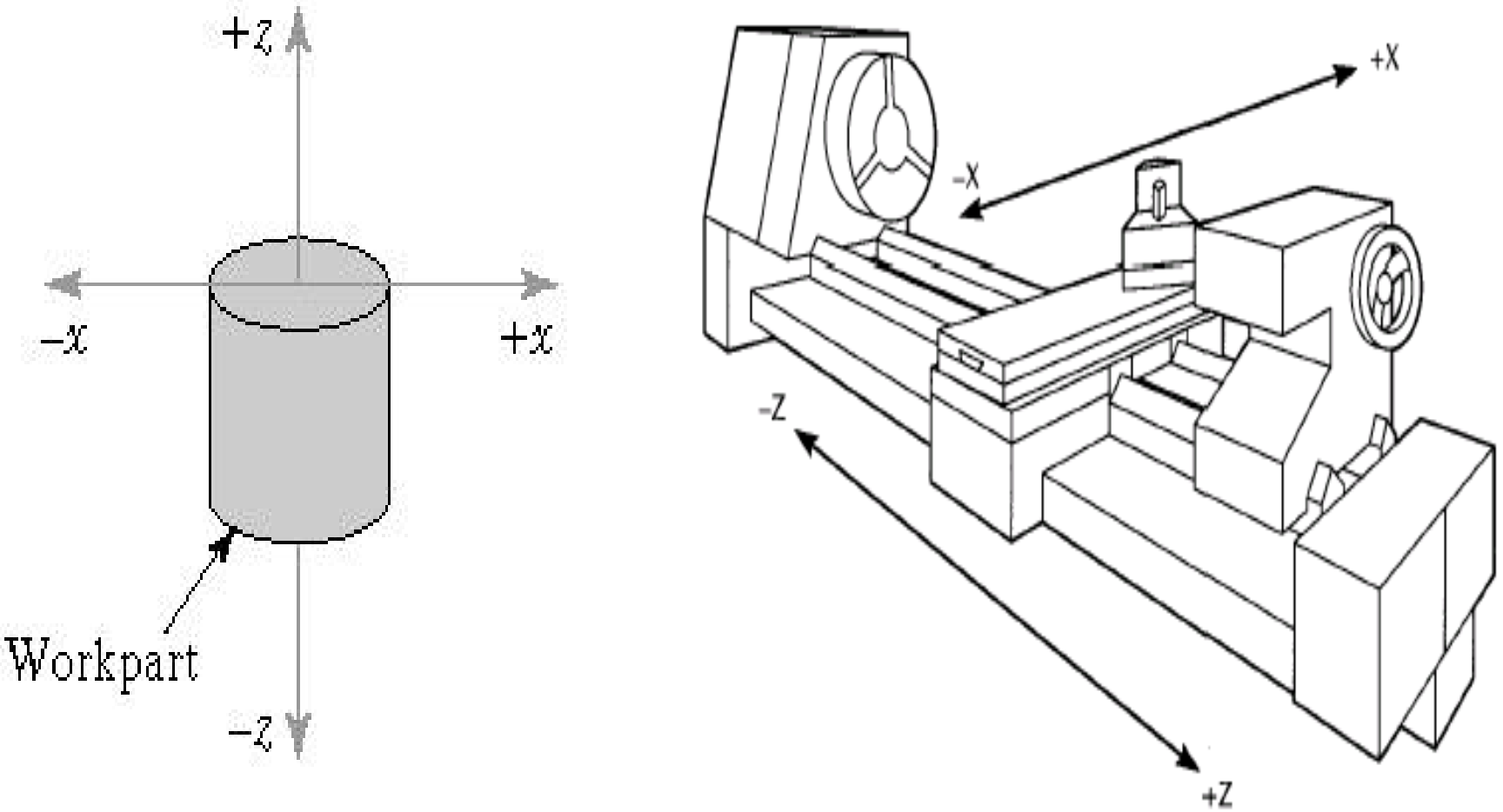
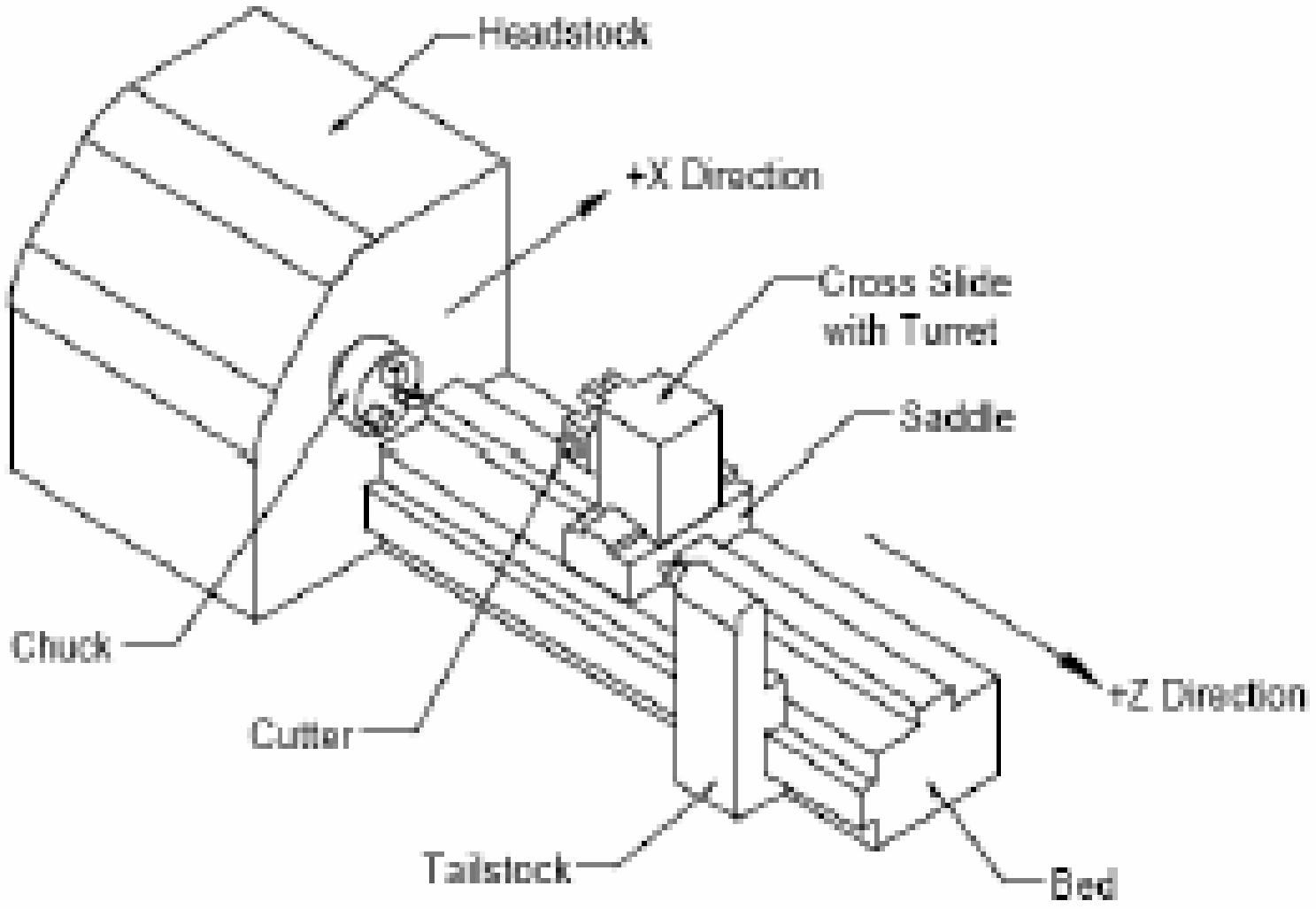


Figure 1.3 : Coordinate System (Turning Operations)

2-Axis Turning Center



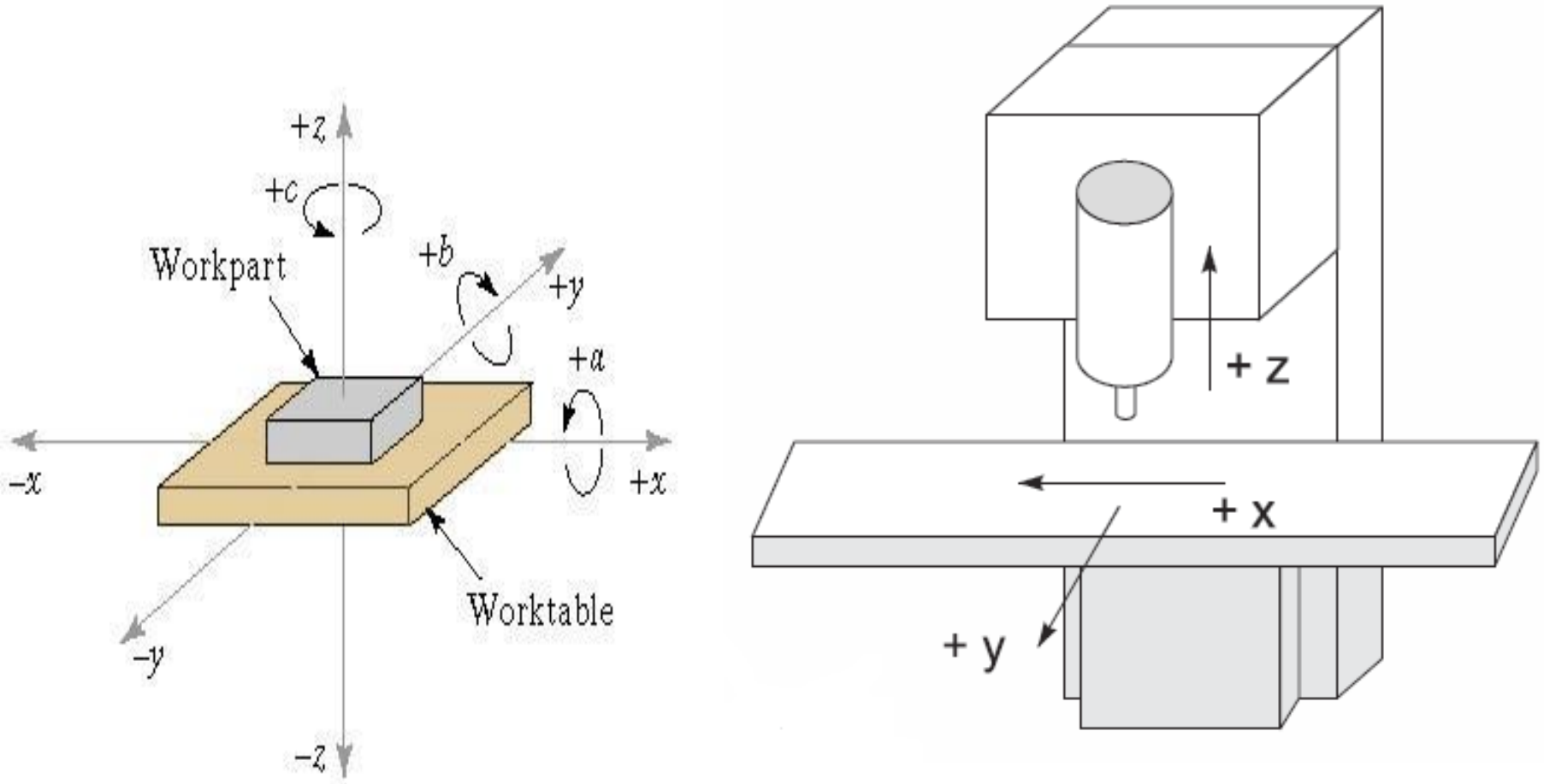
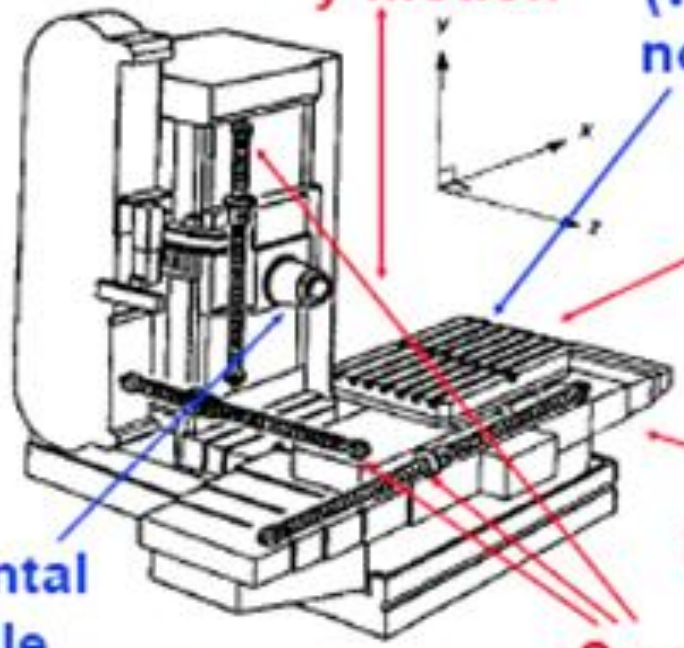


Figure 1.2 : Coordinate System (Milling and Drilling Operations)

3-Axis Machine Tool



CNC MACHINING CENTRE:

1. Vertical Machining Centre (VMC):

- Vertical spindle configuration comprising of three basic servo axes (X - axis, Y-axis & Z - axis): Two for the table movement and one for the spindle head.



2. **Horizontal Machining Centre (HMC):**



- It can perform machining on different faces of a cubical or prismatic component.
- Both VMC and HMC uses **Auto Tool Changer (ATC) & Automatic Pallet Changer (APC)**

Auto Tool Changer (ATC) & Automatic Pallet Changer (APC)

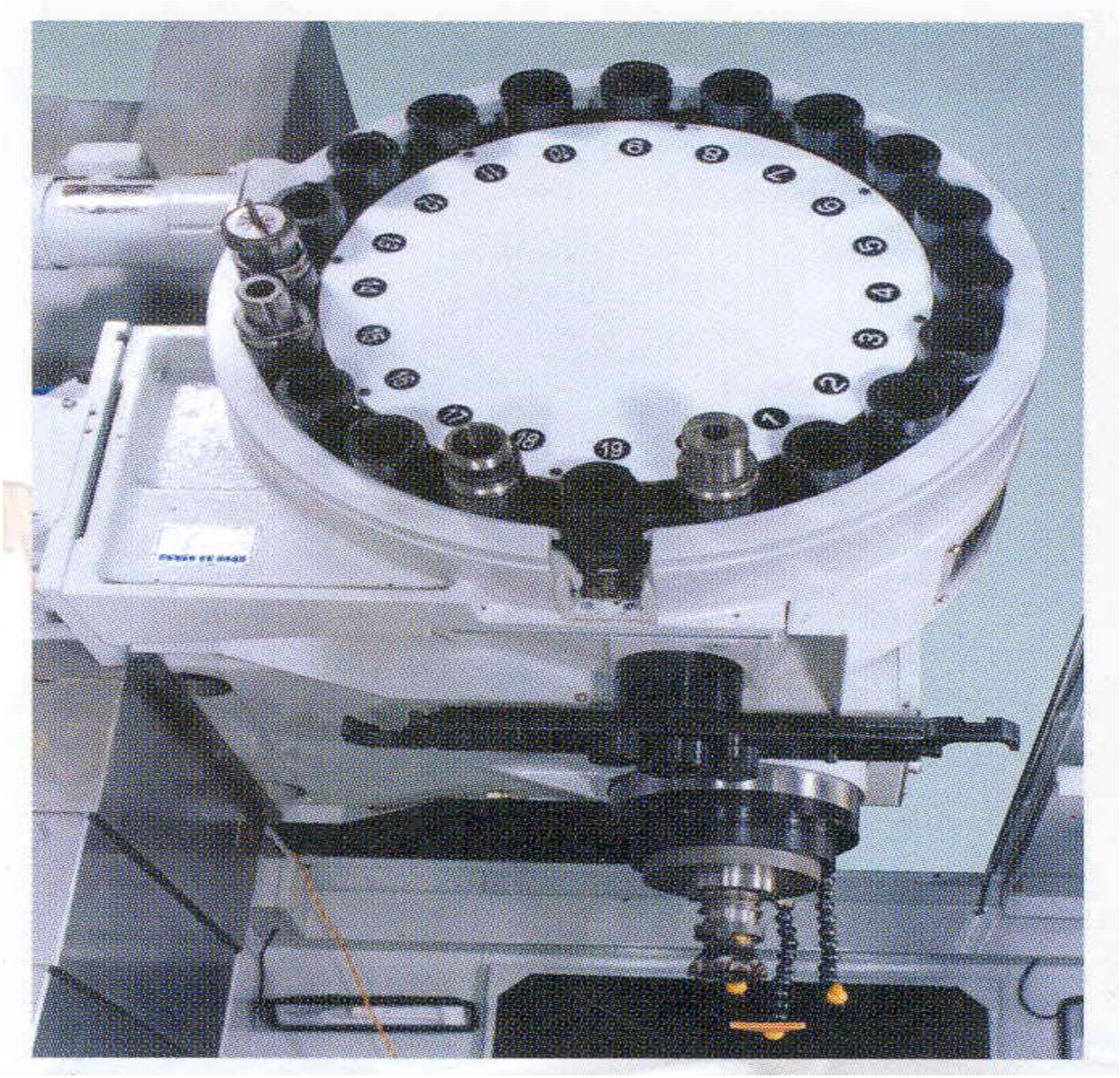
- **ATC (Auto Tool Changer)** is a device which can automatically change the tool from the tool magazine to the machine spindle as per the CNC programme.

- **Tool Magazine** is a device which holds number of tools and can automatically index to enable ATC to pick the right tool and to replace the used tool.

- **Automatic Pallet Changer (APC)** is a device which can automatically change the pallet to/from machine to pallet stand.

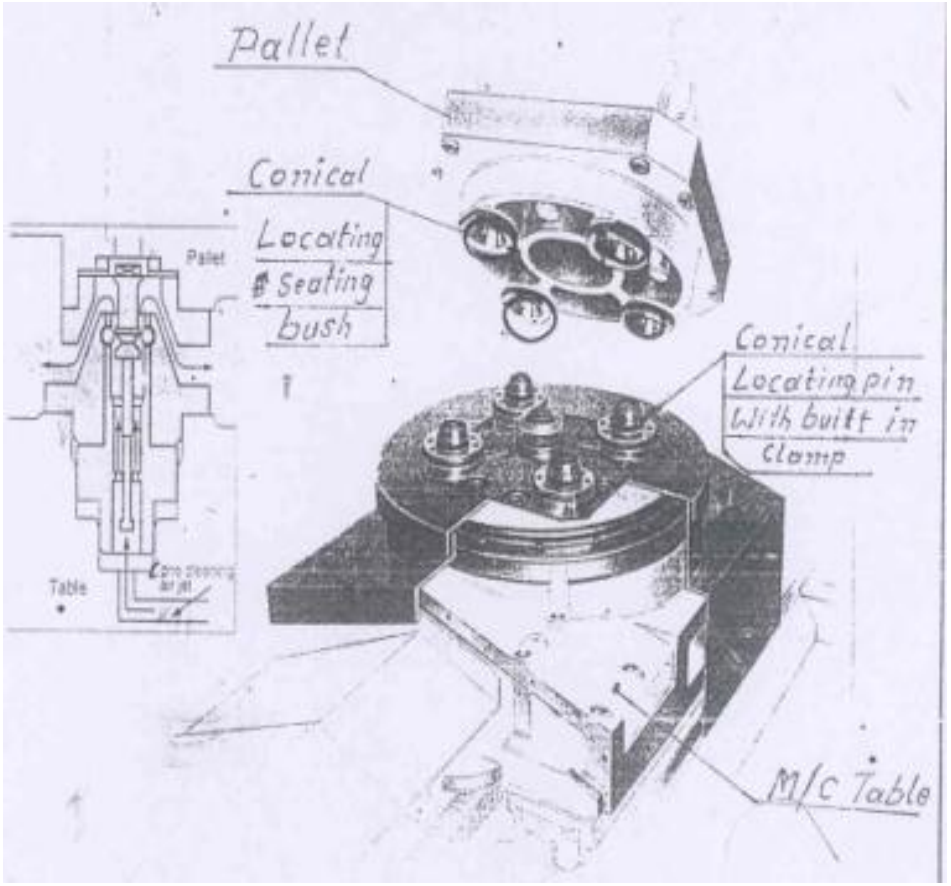
- By this Mechanism **(i .e. APC)** the pallet with the finished component and the pallet with a raw component could be exchanged automatically.

ATC & Tool Magazine



Automatic Pallet Changer (APC)

- Pallet is a transferable work table having `T' slots or tapped holes for component/fixture clamping.
- Used to avoid the machine waiting time during loading & unloading of component.
- Pallet is held on the machine table by locating pins and clamping mechanism to ensure repeatability and accuracy.



3-Axis Machine Tool

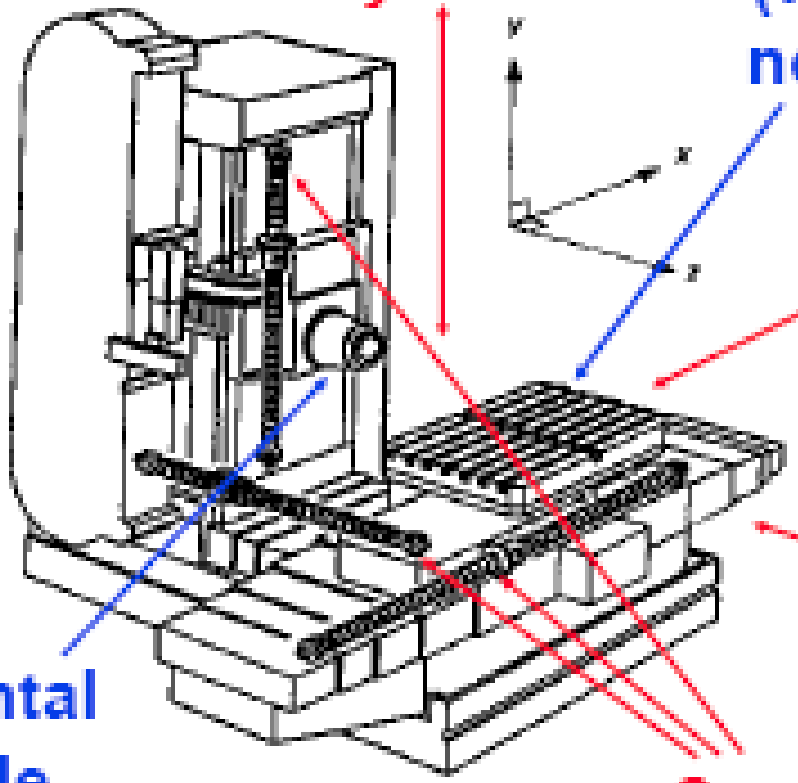


Table (workpiece not shown)

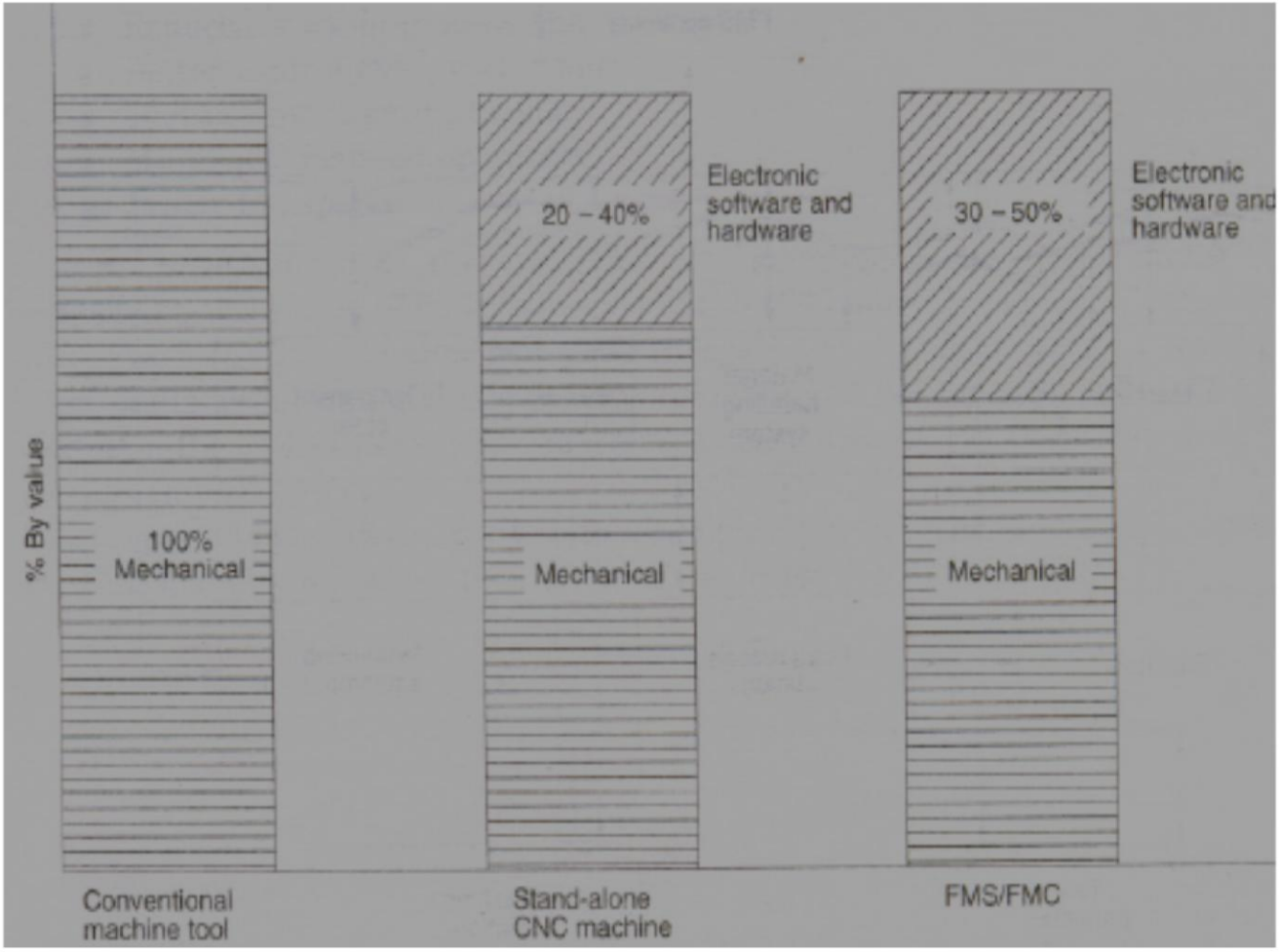
y-motion

x-motion

z-motion

Horizontal spindle (tool not shown)

Screws (drives not shown)



Contents of mechanical and electronic software and hardware in different manufacturing facilities

CNC SYSTEMS

- **Computer Numerical Control (CNC)** is computer based system to store and process data for control of slide motions and auxiliary motions of machine tools.

- CNC Systems are constructed with NC Unit integrated with **HMI, Programmable Logic Controller (PLC) with a 'Feed Back Device'.**

- **PLC** controls the **ON/OFF** functions of the machine tool. It sets the output based on the input conditions & corresponding logic.

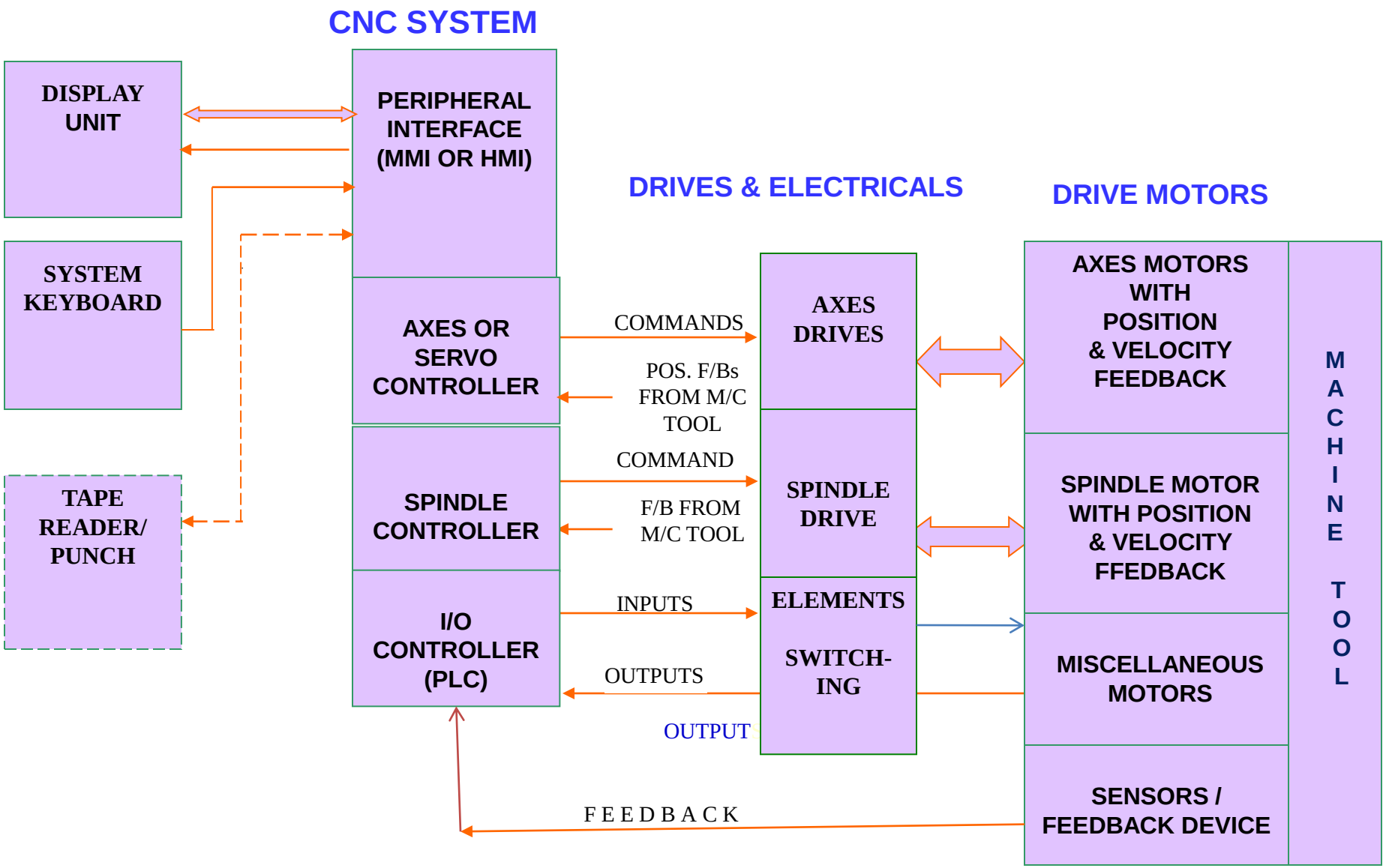
PLC Functions:

- ✓ Coolant ON/OFF.
- ✓ Spindle ON/OFF.
- ✓ Selection of a tool.
- ✓ Change of workpiece (Pallet Changing).
- ✓ Workpiece clamping etc.

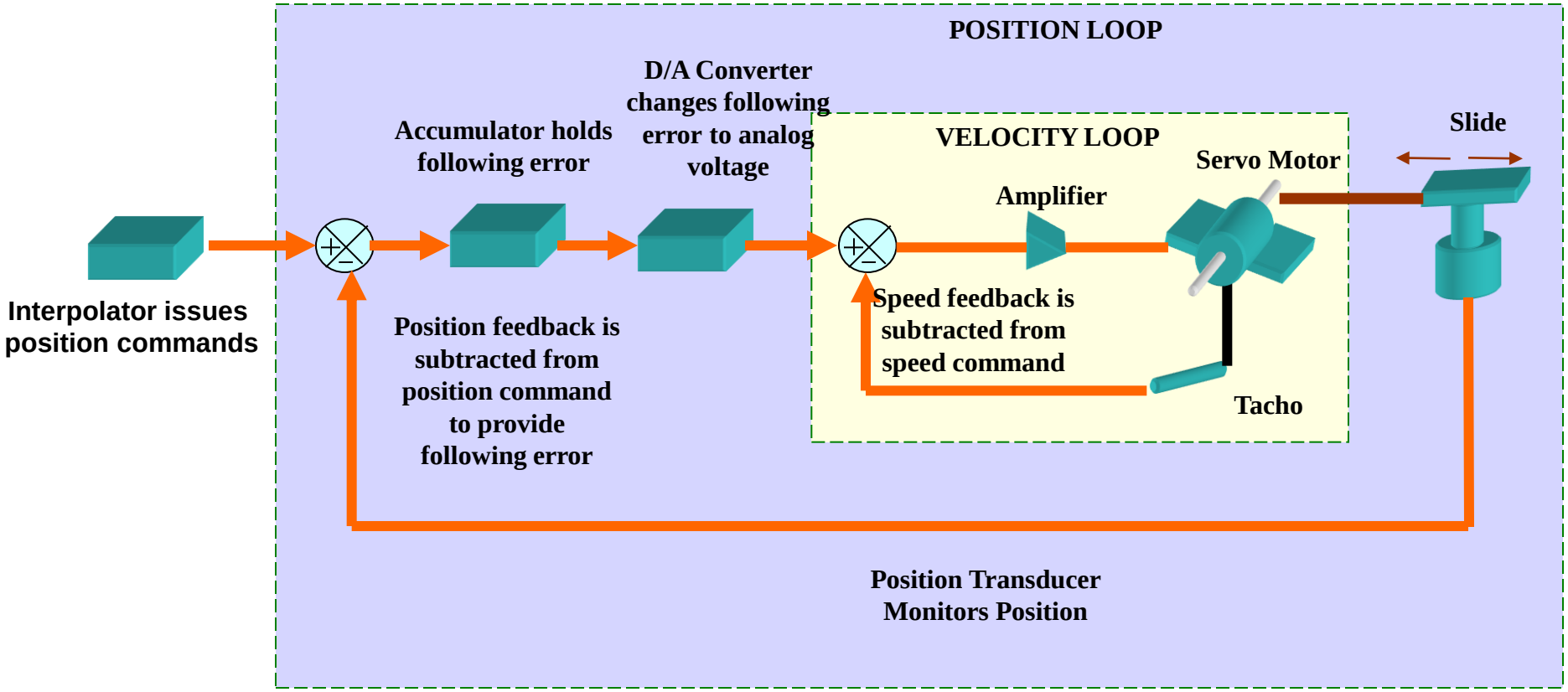
Components of a CNC Machine

- CNC System (Controller)
- Drives.
- Servo Motors
- Actuators
- Sensors/ Feedback devices.

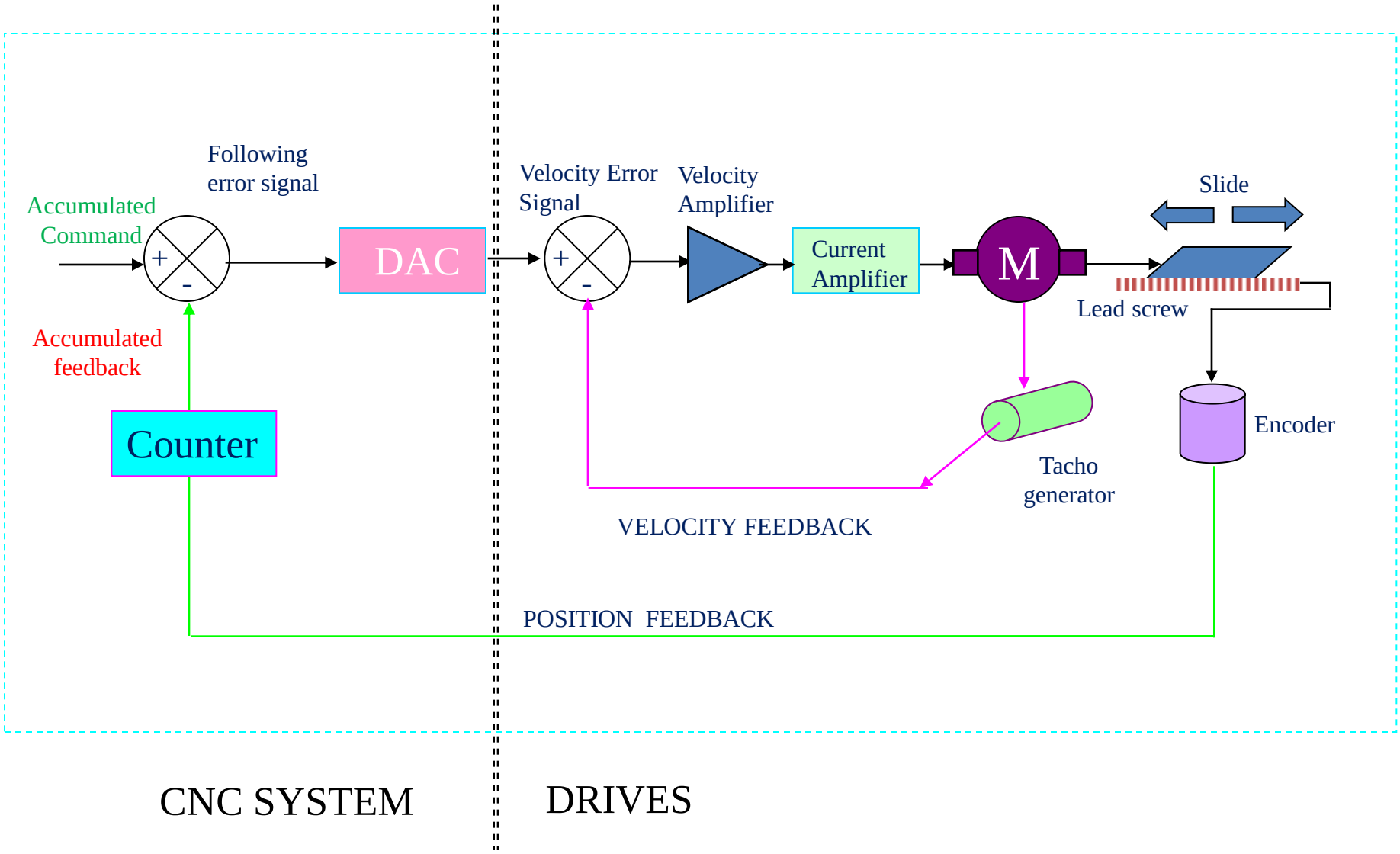
HOW A CNC SYSTEM WORKS ?



CLASSIC SERVO LOOP



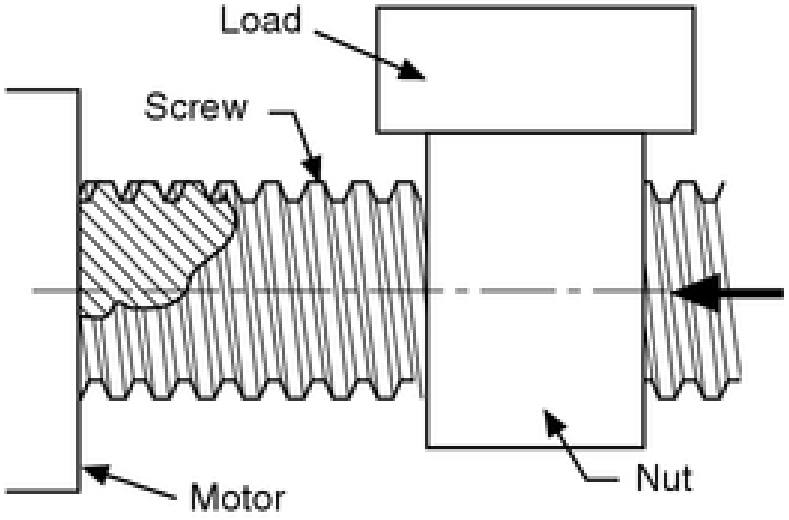
Analog Servo Loop in CNC System



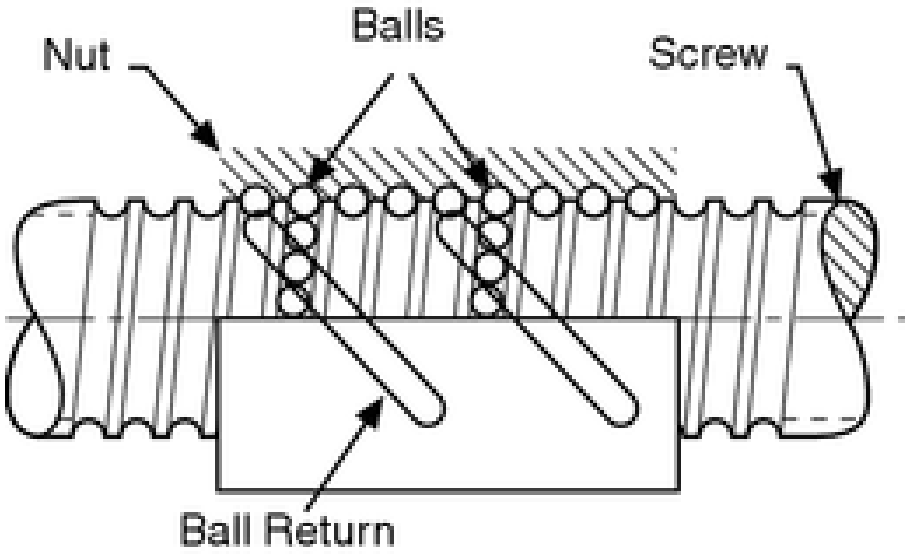
Special Features of CNC M/c

- Mechanical Features:

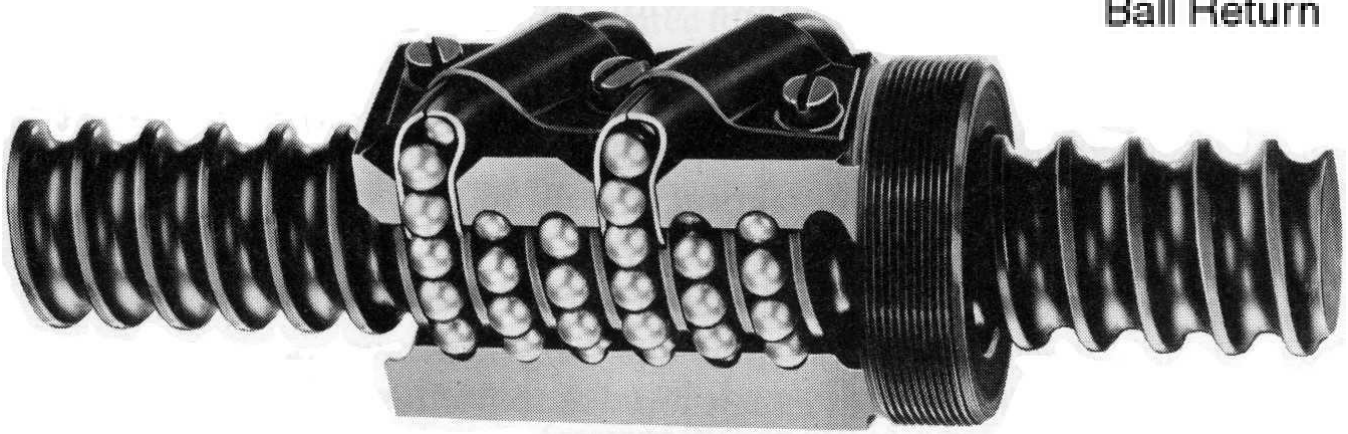
  - » Ball Lead Screws.
  - » Linear Bearings.
  - » Improved Guide ways.
  - » Timing Belts.
  - » Curvic Coupling.



- **Smooth Linear Motion.**
- **Low starting friction.**
- **Wear resistant.**
- **Very Low Backlash.**

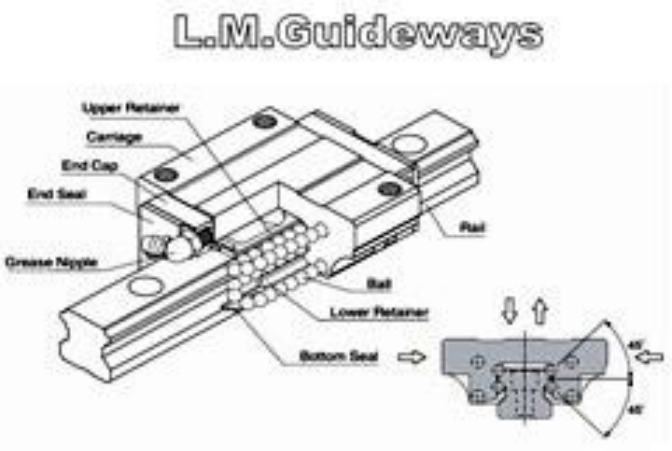


Ball Lead Screws

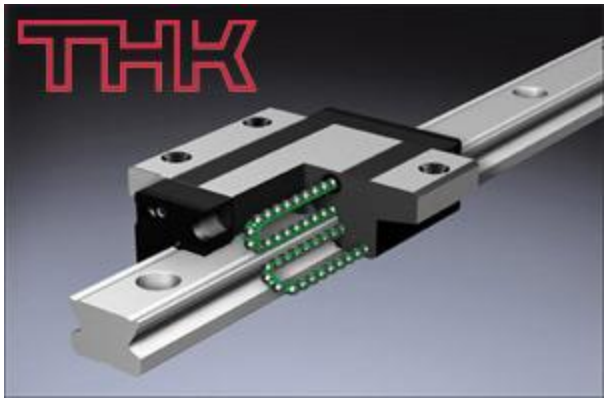


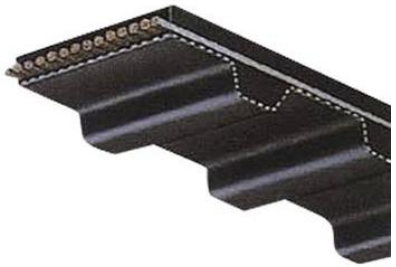
Linear Bearings on guide-ways

- Smooth Linear Motion.
- Low starting friction.
- Wear resistant.





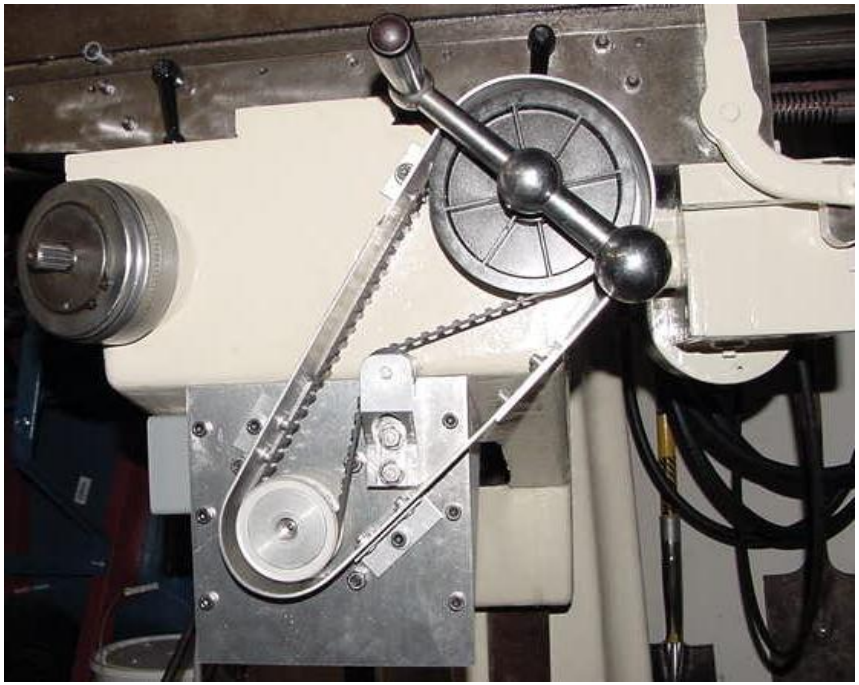




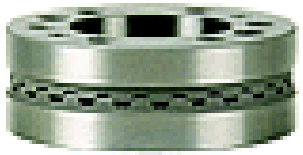
- Toothed Belt, Steel-wires.
- Slip-Proof Drive.







Timing Belt





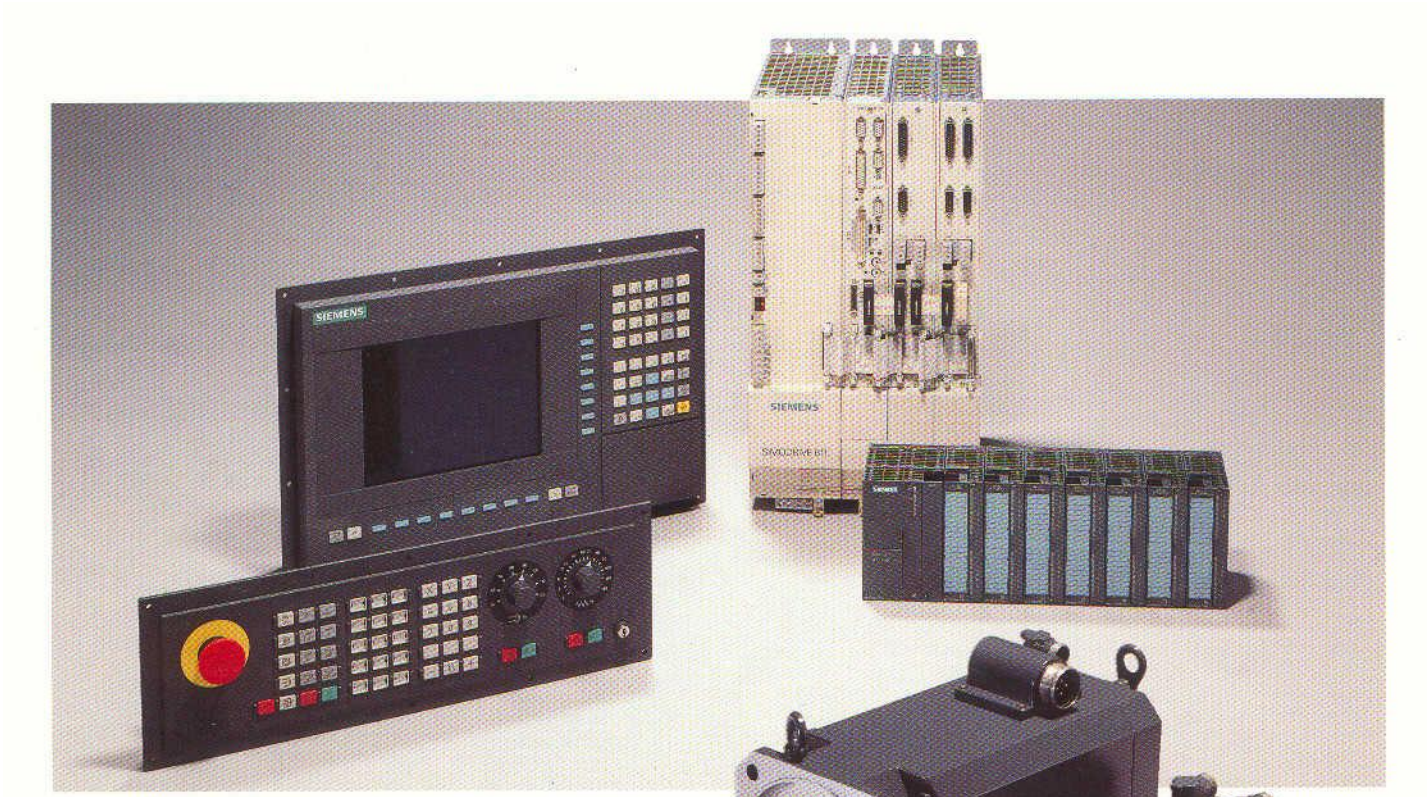
- **Used in Turret Indexing of CNC m/c.**



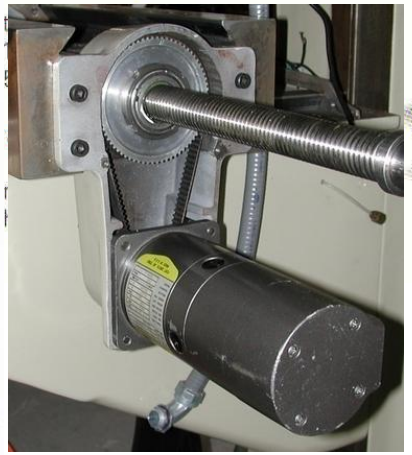


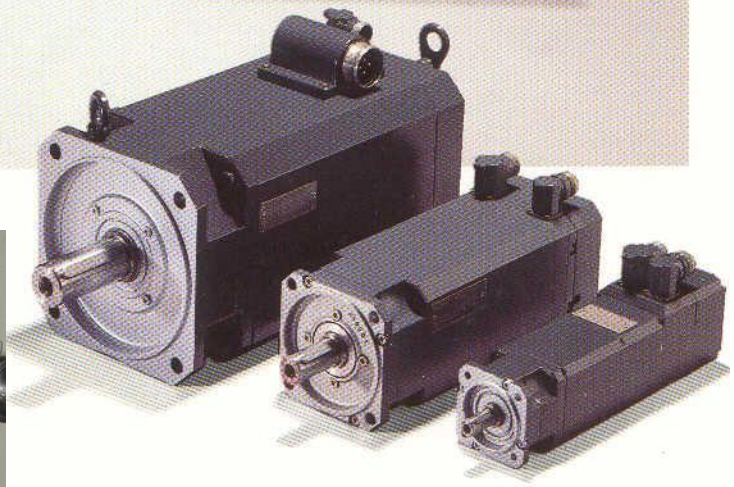
Curvic Coupling



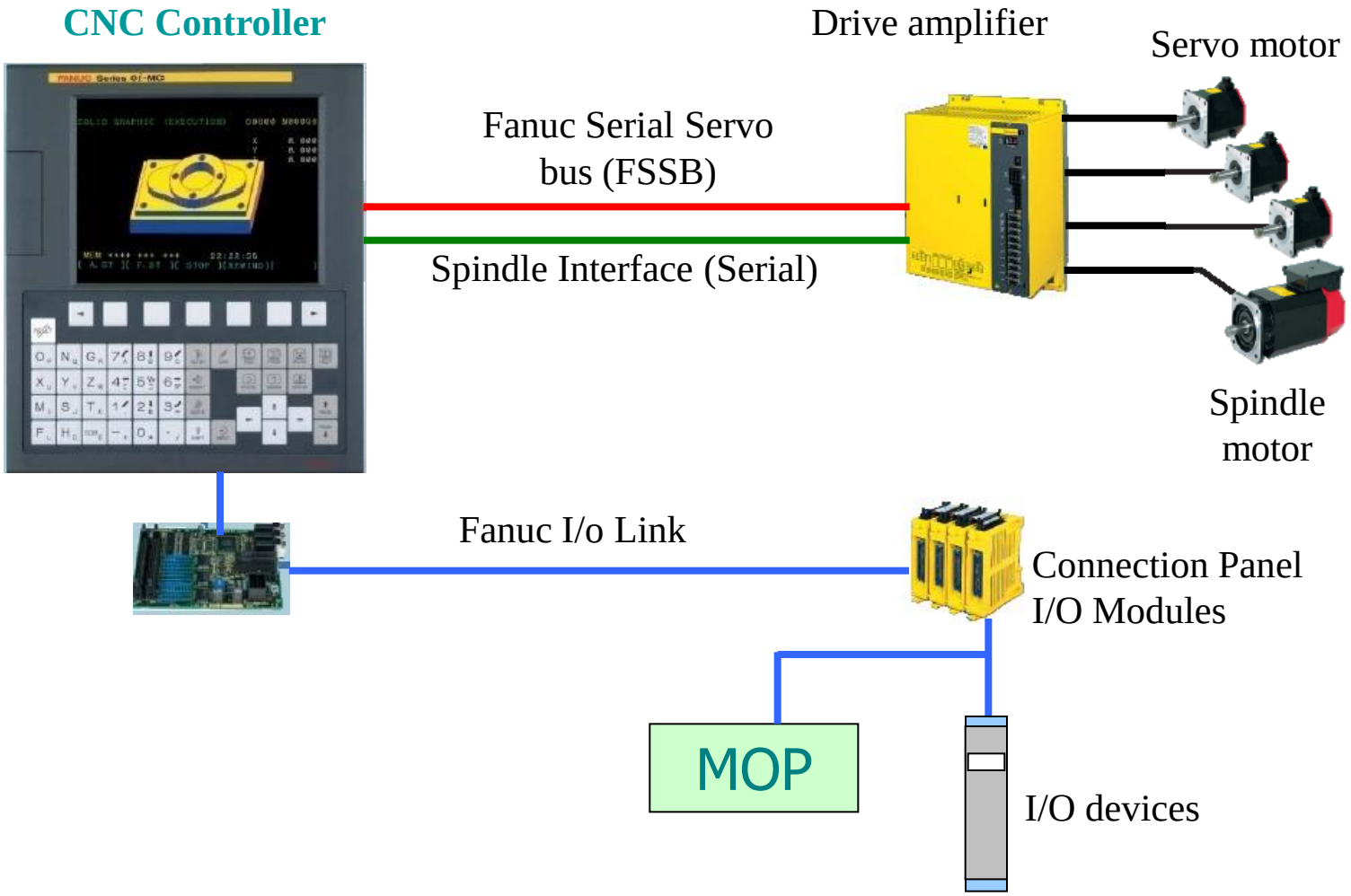

SIEMENS
SIEMENS
SIMODRIVE 611







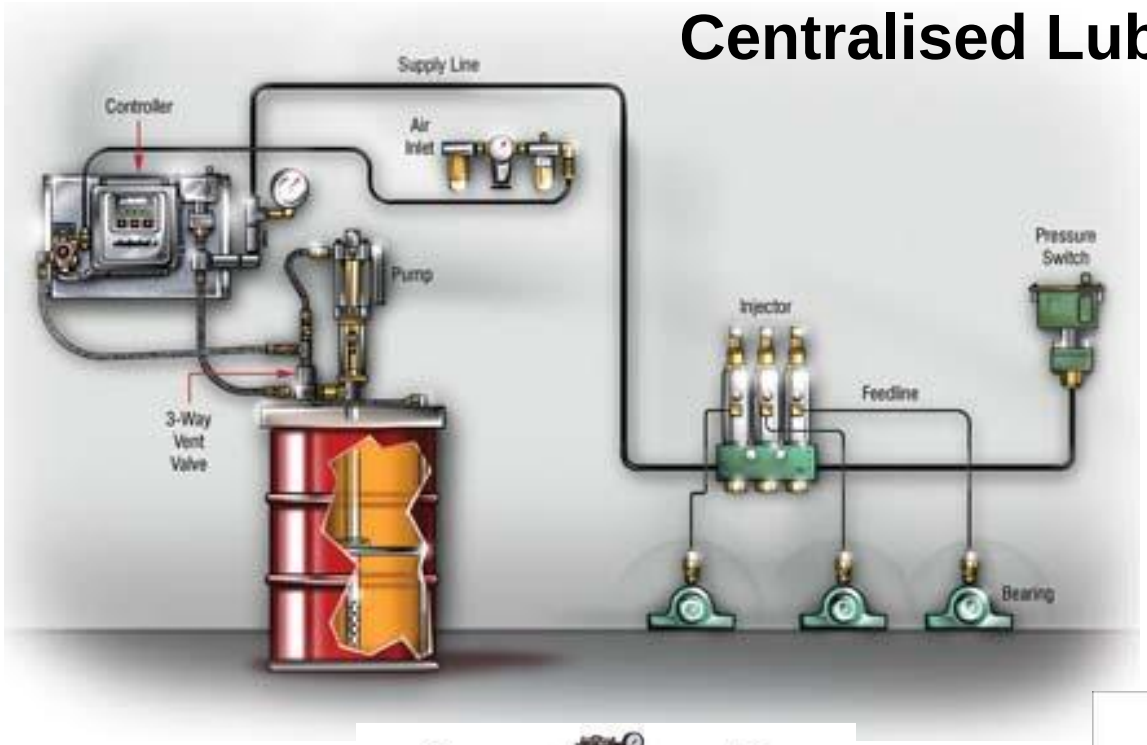
Fanuc Series 0i System



System Features

- Centralized Lubrication System.
- Operating features
- Programming features
- Communication features
- Compensation features
- Safety and diagnostic features

Centralised Lubrication System

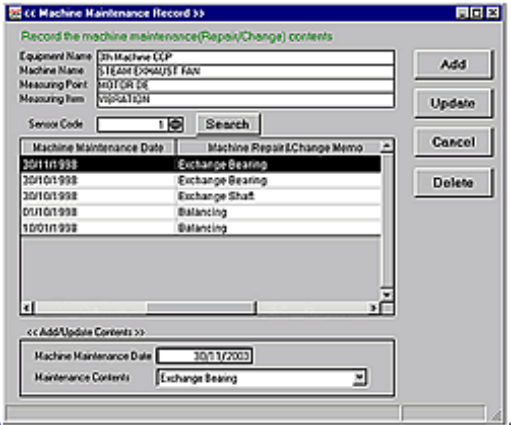


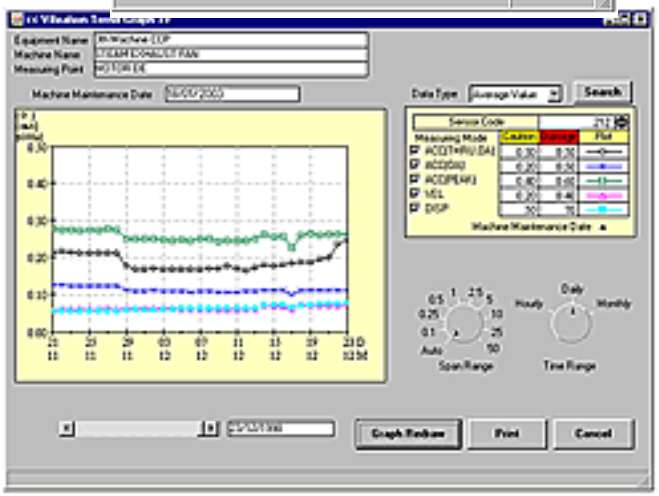


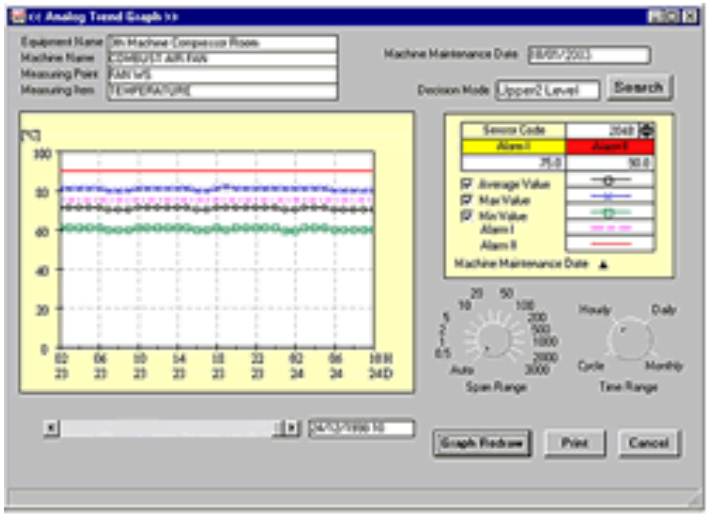


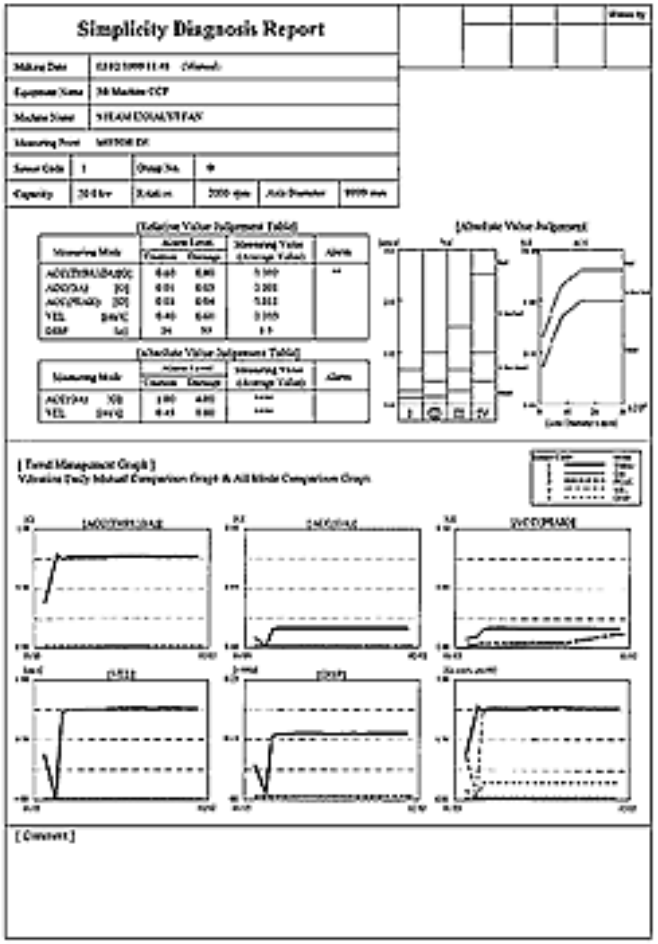
Online Machine Diagnosis System

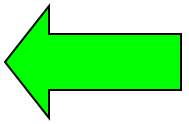
JFE Advantech











Operating Features

Basic Operating Modes:

- JOG Mode
- MDI MODE
- AUTO MODE

JOG MODE

Manual movement of axes.
Manually select the tool.
Manually move the axes.
Find the tool offset.

MDI MODE

Program phase.
Manually feed the program.

AUTO MODE

Create a Program.
Store the Program
Execute the program

Programming Features

- Inch / Metric Programming
- Absolute / Incremental Programming
- Linear / Circular / Helical / Spiral Interpolation
- Full Circle Programming
- Subroutine Programming

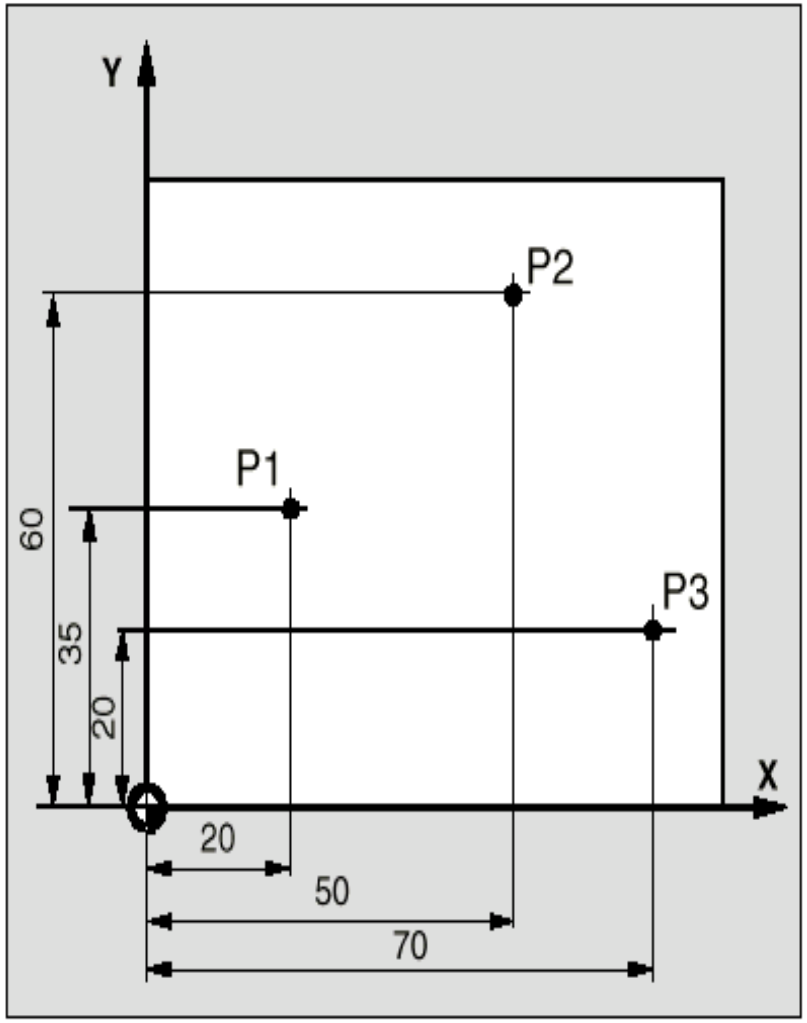
Absolute dimension

With absolute dimensions, all the positional parameters refer to the currently valid zero point. Applied to tool movement this means:

The absolute dimensions describe the position to which the tool is to travel.

Example for milling:
The positional parameters for points P1 to P3 in absolute dimensions **referring to the zero point** are the following:

P1 corresponds to `X20 Y35`
P2 corresponds to `X50 Y60`
P3 corresponds to `X70 Y20`



Incremental dimension

Production drawings are frequently encountered, however, where the dimensions refer not to the origin, but to another point on the workpiece.

In order to avoid having to convert such dimensions, it is possible to specify them in incremental dimensions.

Incremental dimensions refer to the positional data for the previous point. Applied to tool movement this means:

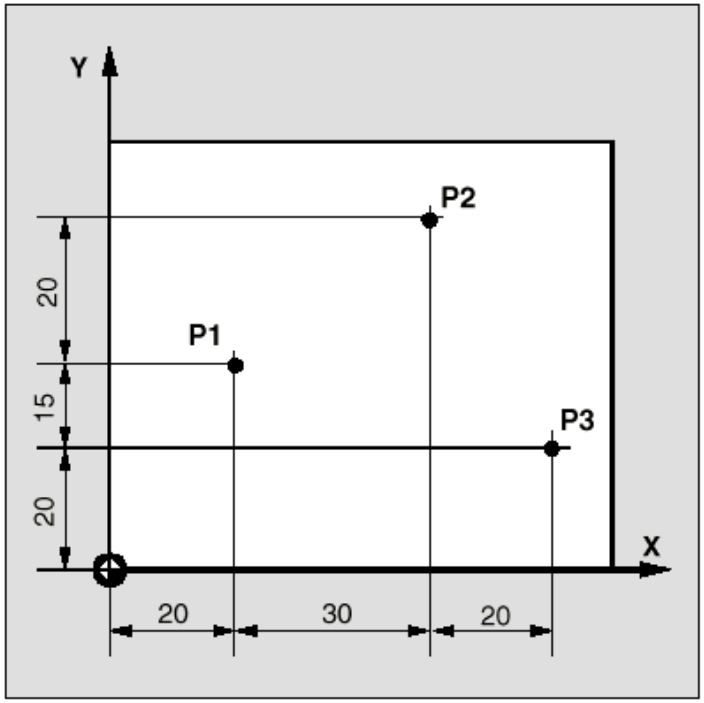
The incremental dimensions describe the distance the tool is to travel.

Example for milling:
The positional data for points P1 to P3 in incremental dimensions are:

P1 corresponds to `X20 Y35` ;(with reference to the zero point)

P2 corresponds to `X30 Y20` ;(with reference to P1)

P3 corresponds to `X20 Y-35` ;(with reference to P2)



Communication Features

- Upload / Download Of Programs

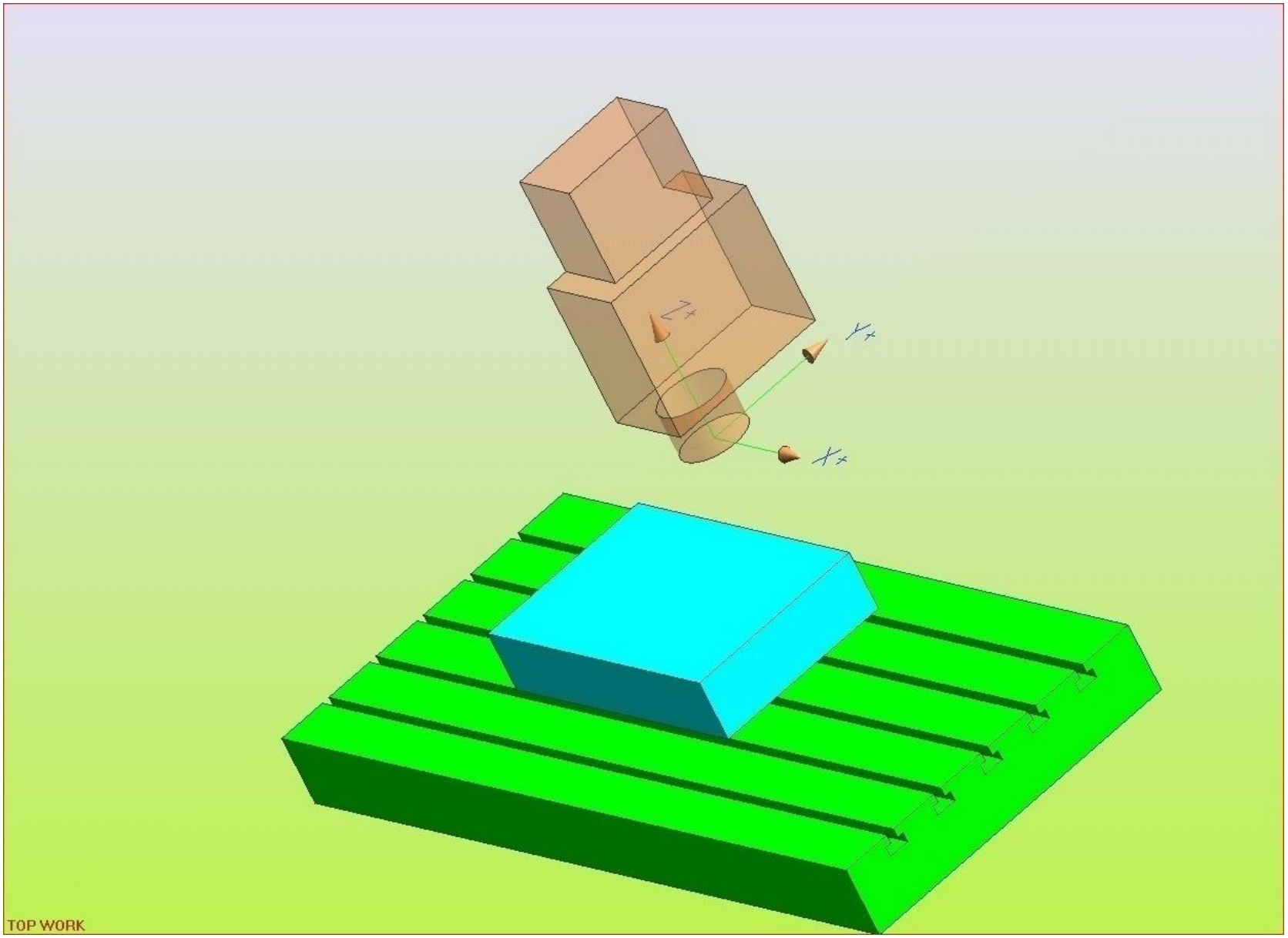
- Machine Status Monitoring

Compensation Features

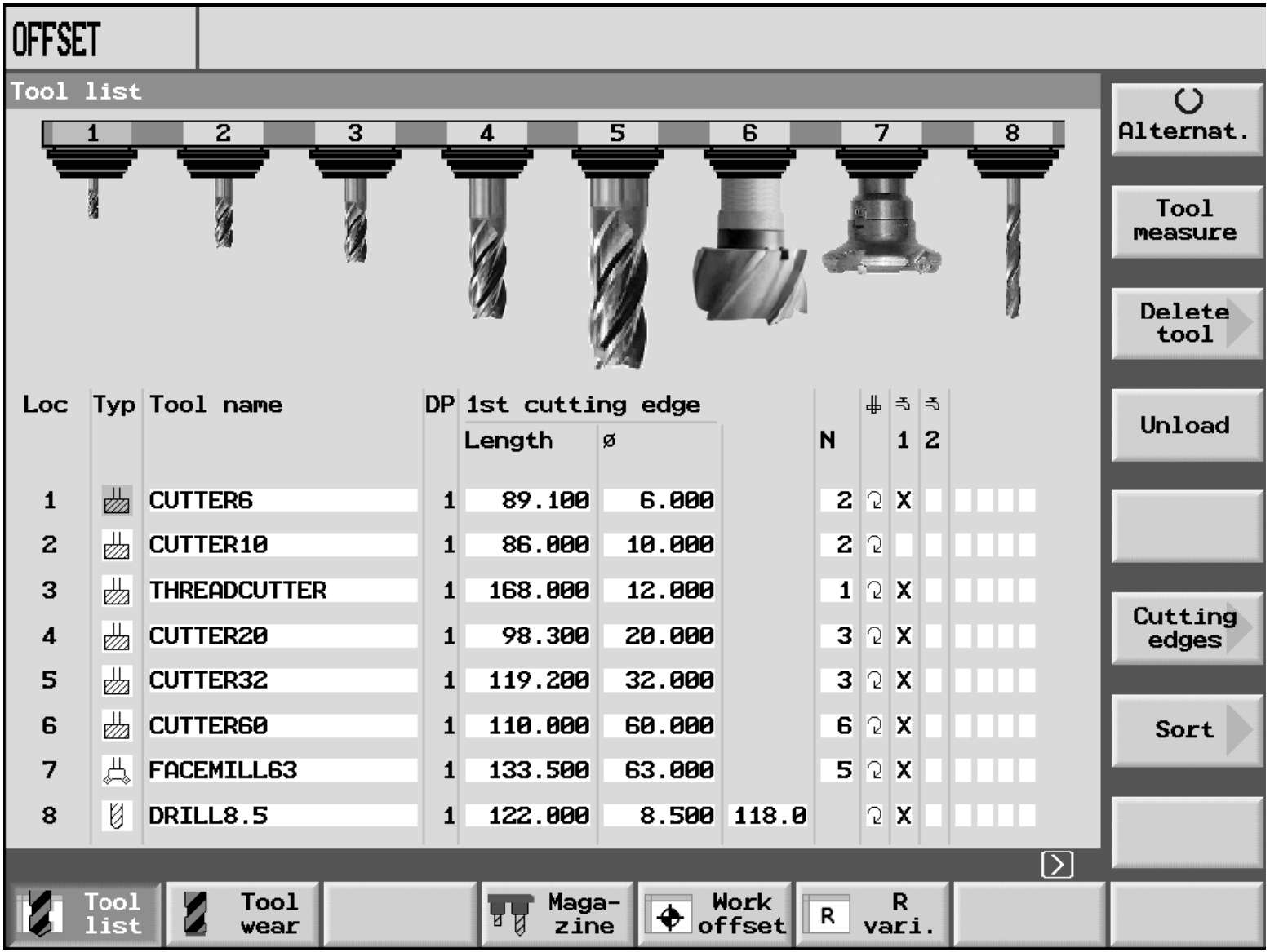
Tool Offset & Work offset

- Tool Length Compensation
- Diameter Compensation

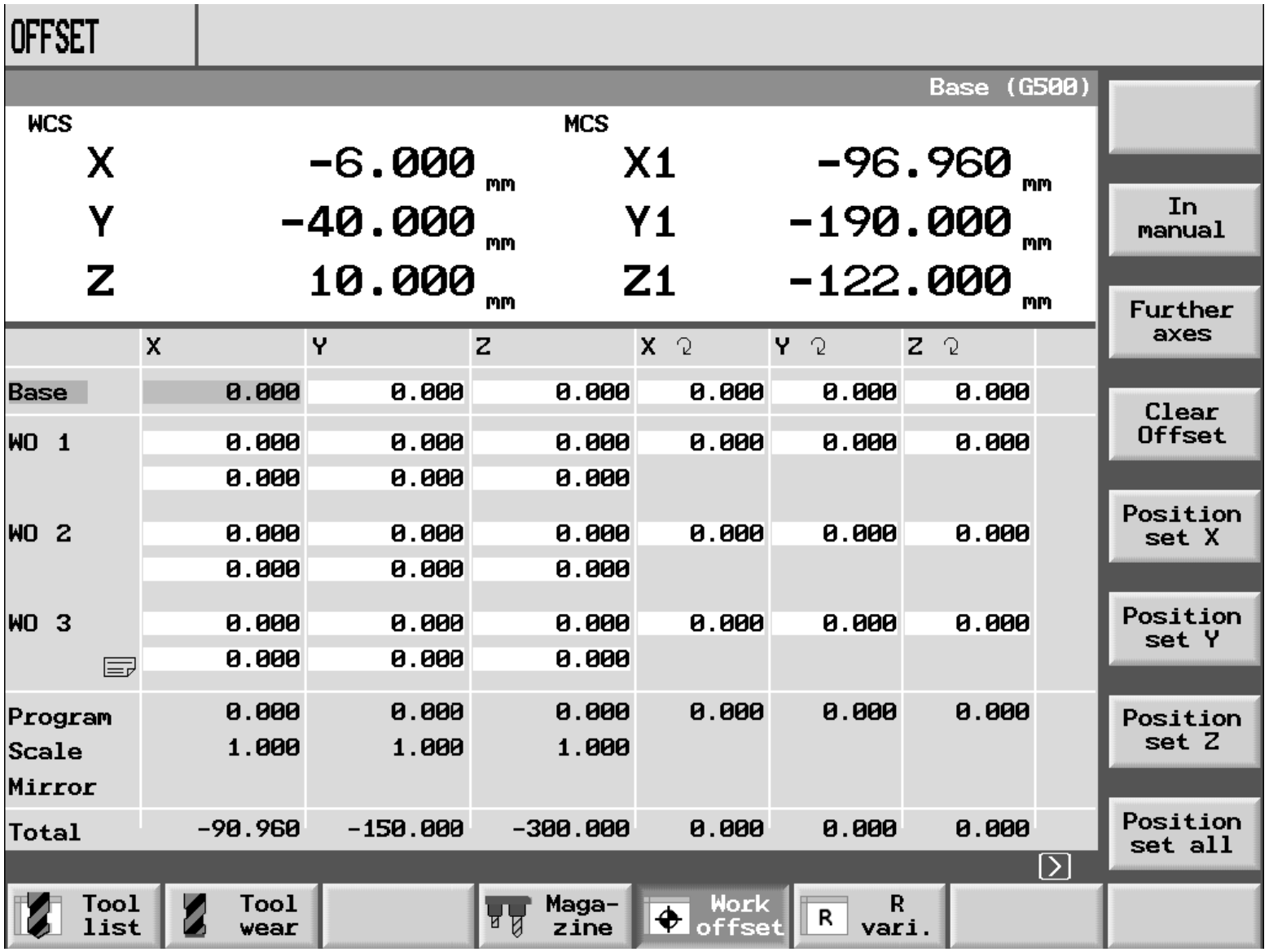
WORK OFFSET



TOOL OFFSET


OFFSET
Tool list
1
2
3
4
5
6
7
8
Alternat.
Tool measure
Delete tool
Unload
Cutting edges
Sort
Loc Typ Tool name DP 1st cutting edge Length ø N 1 2
1 CUTTER6 1 89.100 6.000 2 X
2 CUTTER10 1 86.000 10.000 2
3 THREADCUTTER 1 168.000 12.000 1 X
4 CUTTER20 1 98.300 20.000 3 X
5 CUTTER32 1 119.200 32.000 3 X
6 CUTTER60 1 110.000 60.000 6 X
7 FACEMILL63 1 133.500 63.000 5 X
8 DRILL8.5 1 122.000 8.500 118.0 X
Tool list
Tool wear
Maga-zine
Work offset
R
R vari.

TOOL OFFSET


OFFSET
Base (G500)
WCS
X -6.000 mm
Y -40.000 mm
Z 10.000 mm
MCS
X1 -96.960 mm
Y1 -190.000 mm
Z1 -122.000 mm
X Y Z X ↻ Y ↻ Z ↻
Base 0.000 0.000 0.000 0.000 0.000 0.000
WO 1 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
WO 2 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
WO 3 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
Program 0.000 0.000 0.000 0.000 0.000 0.000
Scale 1.000 1.000 1.000
Mirror
Total -90.960 -150.000 -300.000 0.000 0.000 0.000
In manual
Further axes
Clear Offset
Position set X
Position set Y
Position set Z
Position set all
Tool list
Tool wear
Maga-zine
Work offset
R vari.

Safety And Diagnostic Features

- **Emergency Stop**
- **Axis Overtravel**
- **Power Up Diagnostics**

CNC SYSTEMS

MANUFACTURER	COUNTRY	MODEL
ROCKWELL AUTOMATION	U. S. A	ALLEN BRADLEY 8610, 8650, 9/PC
CINCINNATI MILACRON	U. S. A	ACRAMATIC 950, 2100
FAGOR	SPAIN	FAGOR 800, 8025, 8050
FANUC	JAPAN	FANUC 18i/180i, 21i/210i, 30i/31i/32i, 300i/310i/320i
FANUC INDIA	INDIA	FANUC 0 , 0i
HEIDENHAIN	GERMANY	TNC 155, 426, 430
GSK CNC EQUIPMENT	CHINA	GSK980TDa., GSK983M
SIEMENS	GERMANY	SINUMERIK 802, 840, 880
MITSUBISHI ELECTRIC AUTOMATION INC.	JAPAN	70/700 SERIES, C6/C64 SERIES, 60S/E60/E68 SERIES

CNC PROGRAMMING

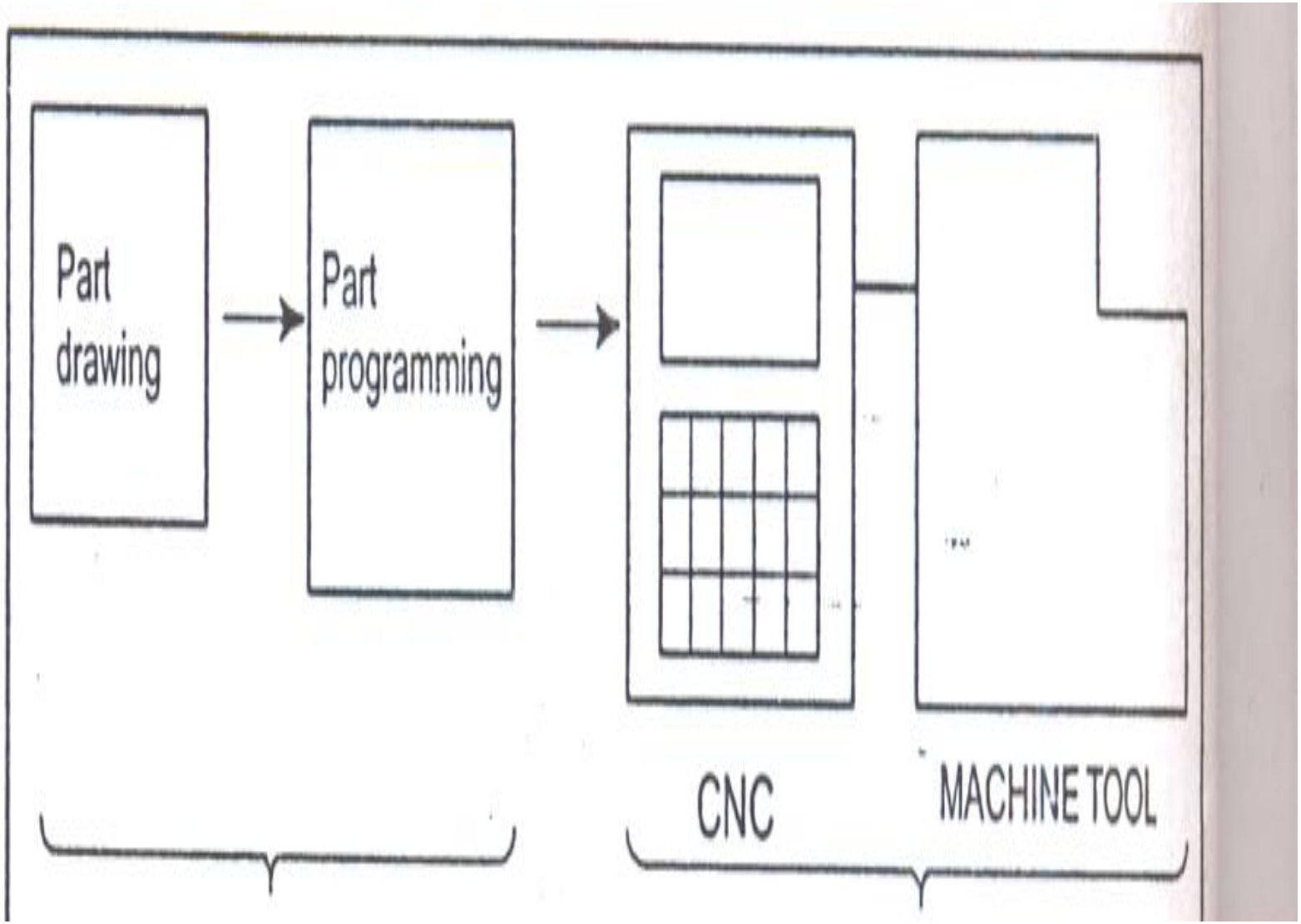
Basic steps in CNC machining:

i) First, prepare the program from part drawing .

(ii) The part program is then read to the CNC system.

(iii) Then the workpiece & tool are mounted on the machine.

(iv) Then the tool is operated according to the programming (Execute the program).


Part drawing
Part programming
CNC
MACHINE TOOL

NC Part Programming Techniques

1. Manual part programming
2. Computer-assisted part programming
3. CAD/CAM- assisted part programming

Common features:

- Points, lines, and surfaces of the workpart must be defined relative to NC axis system
- Movement of the cutting tool must be defined relative to these part features

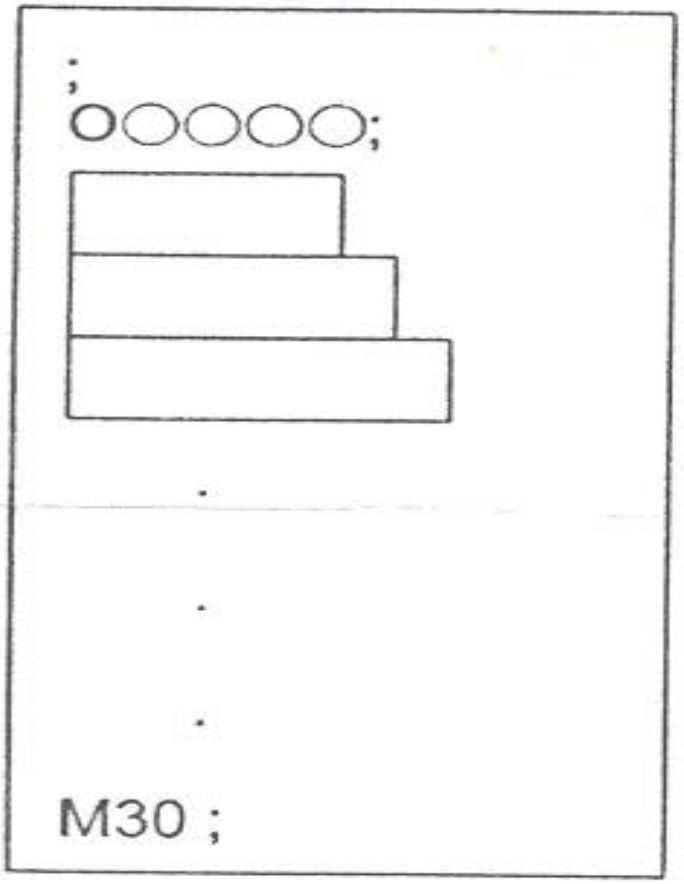
NC Words

A G-code program consists the following words:

N, G, X, Y, Z, I, J, K, F, H, D, S, T, R, M

N - Sequence number (Used for line identification)
G - Preparatory function
X - X axis designation
Y - Y axis designation
Z - Z axis designation
R - Radius designation
F - Feedrate designation
S - Spindle speed designation
H - Tool length offset designation
D - Tool radius offset designation
T - Tool Designation
M - Miscellaneous function (See below)

Program configuration



Program number

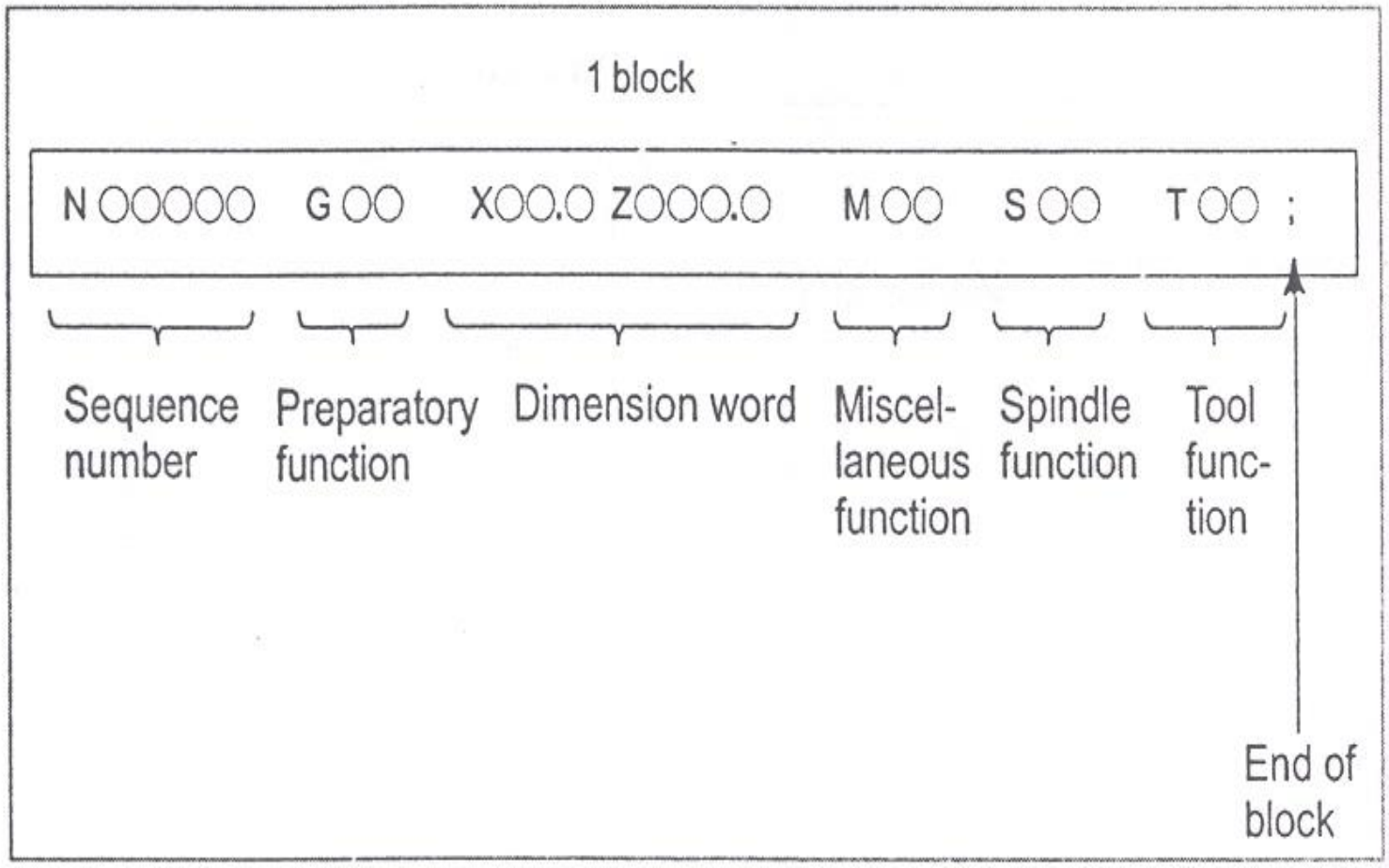
Block

Block

Block

End of program

Block configuration



G - CODES

G-codes are used to move the tool or axes by Program.

G 00 – Rapid travel.

G 01 – Linear interpolation.

G 02 – Circular interpolation clock-wise.

G 03 - Circular interpolation anti-clockwise.

G 04 – Dwell time.

G 20 – Inch data input

G 21 – Metric data input.

G 22 – Stored stroke check on.

G 23 - Stored stroke check off.

G 27 – Reference point return check.

.G 28 – Reference position return.

G 29 – Return from reference point

G 30 – Return to second reference point.

G 31 – Skip function.

G 32 – Thread function.

G 36 – Automatic tool compensation X

G 37 - Automatic tool compensation Z

G 40 – Tool nose radius compensation cancel

G 90 – Absolute dimensioning.

G 91 – Incremental dimensioning.

G 98 – Feed rate in mm/min.

G 99 - Feed rate in mm/rev.

M- CODES (Miscellaneous Codes)

- ON/OFF Codes.
- Controlled by PLC

.

M 00 – Optional stop.

M 01 – Programmable stop.

M 02 – Main program end.

M 03 – Spindle clock-wise.

M 04 – Spindle counter clock-wise.

M 05 – Spindle stop.

M 06 – Tool change.

M 07 – Coolant b on.

M 08 - Coolant a on.

M 10 – Chuck open.

M 11 – Chuck close.

M 13 – Spindle forward & coolant on.

M 14 - Spindle reverse & coolant on.

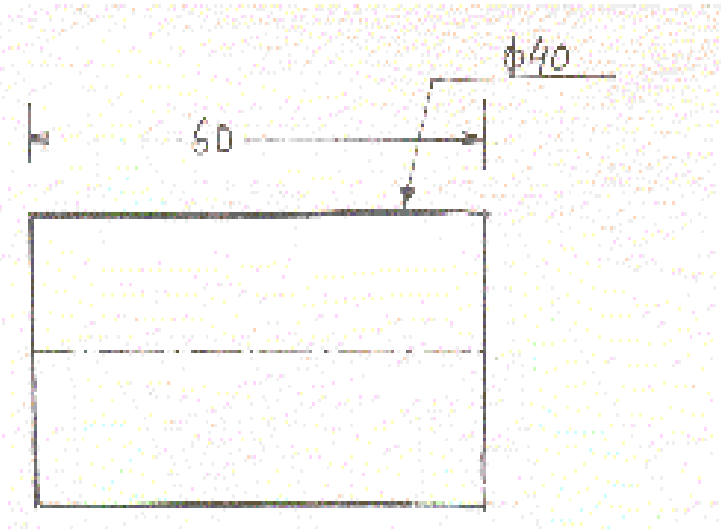
M 16 – Special tool call.

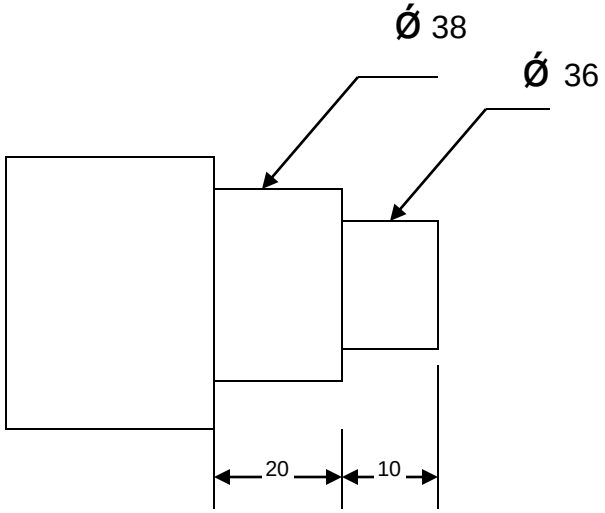
M 17 – Sub-program end.

M 19 – Spindle orientation.

M 30 – Main program end & rewind.

7. A raw material of size: ø 40 and 60 mm. length is supplied to you . Make a CNC part program for step turning of the given job as shown in the diagram.





- Step Turning:

- O 0001;
- N10 G21 G99 ;
- N20 G28 U0.0 W0.0;
- N30 T01 D01 M06 ;
- N40 S1000 M03 ;
- N50 G00 X41.0 ;
- N60 G00 Z0.0 ;
- N70 G01 X0.0 F1.0 ;

N80 G00 Z5.0 ;

N90 G00 X41.0 ;

N100 G00 Z0.0 ;

N110 G01 X38.0 F1.0 ;

N120 G01 Z-30.0 ;

G130 G01 X41.0 F1.0 ;

G140 G00 Z0.0 ;

G150 G01 X36.0 F1.0 ;

N160 G01 Z-10.0 F1.0 ;

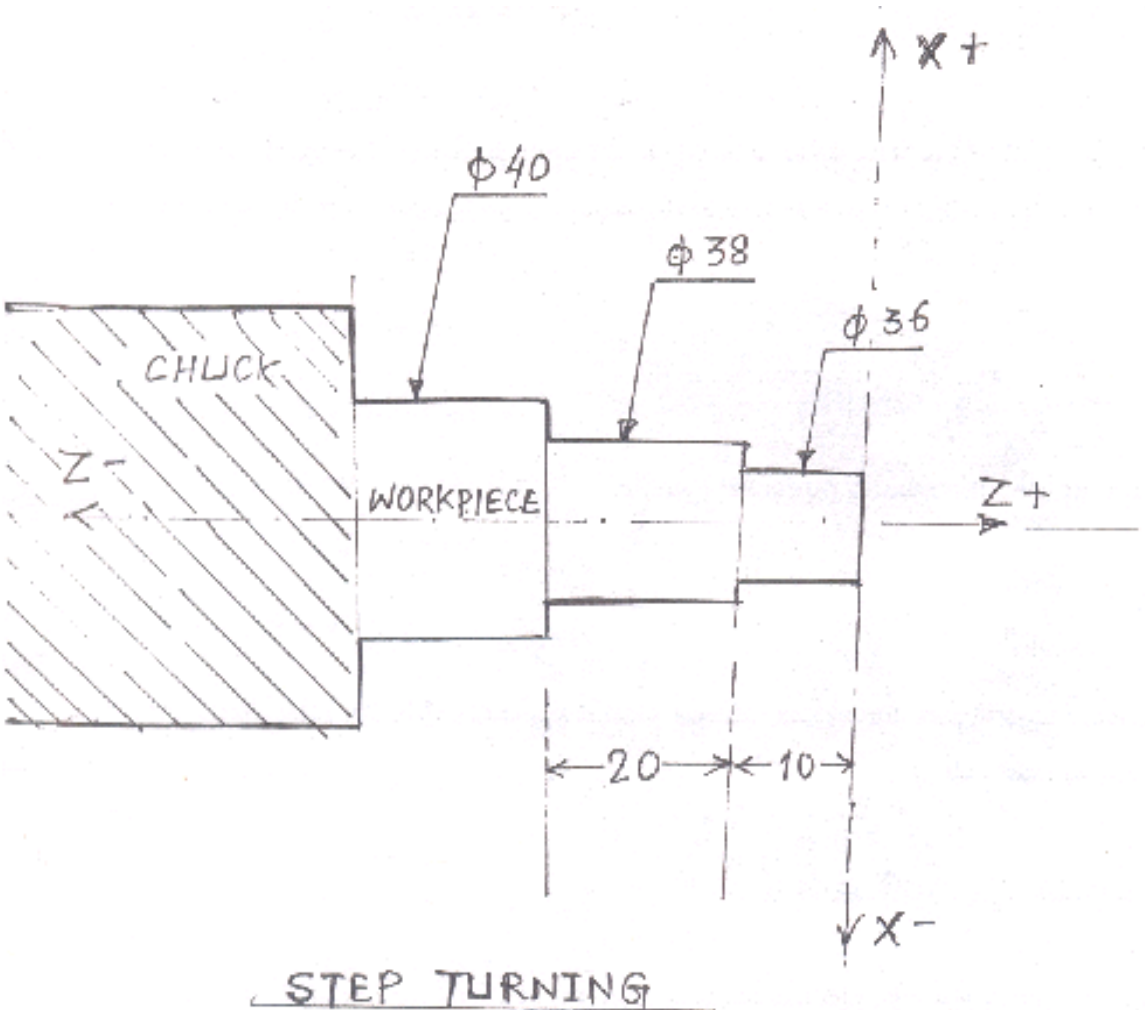
N170 G01 X41.0 F1.0 ;

N180 G00 Z0.0 ;

N190 G28 U_0 W_0 ;

N200 M05 ;

N219 M30 .



THANK YOU