2. ADVANCE MACHINING METHOD

LIMITATIONS OF CONVENTIONAL MACHINING PROCESS:

1. $Quality \propto Quality\ of\ human\ operator$
2. 100% Inspection required.
3. Productivity decreases due to human.
4. Quality or dimensional accuracy or surface finish can't obtain.
5. Complex Shapes can't manufacture.
6. Labour Union impacts to company.
7. Frequent design change can't incorporate immediately.

CUTTING SPEED: It's speed at which the cutting edge passes over the material. (mm or m/min or s)

FEED RATE: It's the distance the tool advances into or along the workpiece each time the tool point passes a certain position in it travel over the surface. (mm or m/min or s or stroke)

THREAD PITCH: It refers to the distance between threads and is expressed in millimetres.

LEAD: Linear Distance travel by nut in one complete revolution is called lead.

$$\boldsymbol{Lead = n * Pitch, where\ n = No.of\ start}$$

BASIC COMPONENTS OF AUTOMATIC MACHINING SYSTEM:

Program of instructions =>	**Machine Control Unit =>**	**Processing Equipment**
Programming language is developed	**Acts as brain**	
Called a part program in machining	Controls the process	Performs the Process

NUMERICALLY CONTROLLED MACHINE TOOL (NC): It consists of 1) CPU or MCU, 2) Drive unit, 3) FBD (Feed Back Device), 4) Manual Control, 5) TRS (Tap reading system)

<table>
<tr><td>Tap Reader System</td><td rowspan="2">CPU or MCU</td><td rowspan="2">Motor</td><td>Workpiece</td></tr>
<tr><td>Manual Control</td><td>Lead Screw</td></tr>
<tr><td></td><td colspan="3">Feed Back System</td></tr>
</table>

1. CPU or MCU:

CPU Send signals to Electrical circular Encoder and it generates required electrical pulsed for motor and send to motor. ALU (Arithmetic logic unit) is utilised for high level decimal system of information to binary for understanding CPU. Pulses can be sent in integer number. **So, minimum number of pulses can be sent is one.**

2. DRIVE UNIT (MOTOR): It converts from Electrical pulse to mechanical work.

- **A. Induction Motor:** It rotates at constant RPM. So, feed rate remains constant which is not preferable. 1951 United State of Air force has developed first NC.

$$\boldsymbol{Feed\ Rate = Motor\ RPM * Lead}$$

- **B. Stepper Motor:** It's used in NC. Because $RPM \propto Input\ Electrical\ Pulses$. But accuracy of the Step is less. Due to energy loss.

$$\boldsymbol{No\ of\ Steps\ required\ to\ rotate\ one\ revolution = 360/Angle\ of\ Step}.$$

- **C. Servo Motor:** It's used in CNC. It has additional system (Quick acting braking system) than stepper motor. Hence, Machining accuracy is very high.

CNC MACHINE IS MORE ACCURATE OR ACCURACY IS MORE COMPARE TO NC MACHINE.

Basic Length Unit (BLU): It's a minimum distance travel by worktable or tool by sending 1 minimum electric pulse.

<table>
<tr><td>$Accuracy \propto (Least\ Count)^{-1} \propto (BLU)^{-1}$</td><td rowspan="2">Maximum Positional Error/ Control Resolution/ Positional accuracy = 1 BLU</td></tr>
<tr><td>Distance travelled/ Feed Rate = Pulse per second * BLU</td></tr>
</table>

Methods to change BLU:

1. By changing pitch of lead screw: It's not practical.
2. By installing Gear Box between motor shaft and lead screw:

$Gear\ Ratio = Output/Input$	Distance travelled/ Feed Rate = No. of Pulses * BLU *Gear ratio /Time

FREQUENCY OF PULSE GENERATOR: It's No. of electrical pulses generated or sand in stipulated time.

$$Feed\ Rate = Frequency\ of\ Pulse\ Generator * BLU * Gear\ ratio$$

BLU is independent of Frequency of pulse generator.

3. **FEED BACK DEVICE (FBD):** Optical Encoder is used as feed back device in NC machine. And Linear Variable Distance Transformer (LVDT) is used in CNC machine.
4. **MANUAL CONTROL:** It's operations which can only done by humans in NC/CNC. E.g. Program feeding.
5. **TAP READING SYSTEM (TRS):** LED light passed through Tap holes and receiver gains instruction (in the Binary information form) and to Machine control system.

Why NC?	Advantages of NC:	Limitations of NC:
• For the parts having complex counters, that can't be manufactured by conventional machine tool. • For jobs requiring very high accuracy and repeatability. • For jobs requiring many setups and/ or the setup very expensive. • The parts that are subjected to frequent design changes are consequently require more expensive manufacturing method. • Inspection time is reduced, since all the parts in a batch would be identical provided proper case is taken about the tool compensations.	• Non-productive time is reduced. • Greater accuracy and repeatability. • Low scrap rate (Wastage) • Inspection requirements are reduced. • More complex part geometries are possible • Engineering changes are easier to make • Simple fixtures • Shorter lead time. • Reduce parts inventory and uses less floor space. • Operator skill level requirements are reduced.	• High investment cost. • High maintenance effort. • Part Programming awareness issue. • Need for skilled programmer. • Time investment for each required for each new part. • **Repeat orders are easy because part program is readily available.**

COMPUTER NUMERICAL CONTROL (CNC):

Hard wire connected processing unit in NC is replaced by minicomputer. And mini computer uses part programming called as G and M code.

CLASSIFICATION OF NC MACHINE:

A. Based on Control Loops 1. Open Loop NC Machine 2. Closed Loop NC Machine: More Accurate. Linear Variable Distance Transformer or optical encoder is used as feedback device.	**B. Based on Motion control system** 1. PTP (Point to point) Control Motion control system E.g. Drilling, tapping, Reaming, Spot Welding, Punching Blanking 2. Continuous Path Motion control system E.g. Straight/ Taper Turning, Milling, planning, Shaping, Grinding.
C. Based on Axis movement 1. Simultaneous Axis movement $R_{feed} = \sqrt{X_{feed}^2 + Y_{feed}^2 + Z_{feed}^2}$ 2. Single Axis movement	**D. Based on Shape produce** 1. Straight line control system: Linear motion of tool 2. Counter line control system: Curvature or counter motion of tool Accuracy of Curvature $\propto (Interpolation\ Distance)^{-1}$

INTERPOLATION DISTANCE: It's Minimum linear distance travelled to create counter shape.

Inside Tolerance	Outside Tolerance	Tolerance Band = I.T. + O.T.
Tool travels inside	Tool travels outside	Tool travels in between tolerance

INTERPOLATION CONTROLLING THE FEED-RATES ACROSS AXIS.

1. Linear and circular interpolation are most commonly used in CNC Programming applications.
2. Linear interpolation is used for straight line machining between two points.
3. Circular interpolation is used for circle and arcs.
4. Helical interpolation is used for threads and helical forms, is available on many CNC machines.
5. Parabolic and cubic interpolations are used by many industries that manufactures parts having complex shapes such as aerospace parts, turbine blades, etc…

MANUAL PART PROGRAMMING

G-Code = General Purpose/ Preparatory Code Used to control movement of the tool.	**M-Code** = Machine/ Miscellaneous Code Used to control machine related function.

STRUCTURE OF CODE:								mm	mm or inch/min	
N01	G00	X ePT	Y ePT	Z ePT						EOB/LF/;
N02	G01	X sPT	Y sPT	Z sPT	X ePT	Y ePT	Z ePT		F300	EOB/LF/;
N03	G02	X sPT	Y sPT	Z sPT	X ePT	Y ePT	Z ePT	R r	F300	EOB/LF/;
N04	G03	X sPT	Y sPT	Z sPT	X ePT	Y ePT	Z ePT	R r	F300	EOB/LF/;
N05	M04								S500 (rpm)	EOB/LF/;
N06	M06								T14 (Tool No)	EOB/LF/;
Sequence/ series/ Block Number										

EOB	End of Block,	G40	Cancellation of tool Radius Compensation.	M00	Program Stop (Turn on Console Switch for resuming)
LF	Line Feeded.				
G00	Rapid Traverse or Rapid Position of tool. (Idle movement of tool).	G41	Tool Radius Compensation Left	M01	Optional Program Stop(Turn on Console Switch for resuming)
G01	Linear Interpolation.	G42	Tool Radius Compensation Right	M02	End of Program (Machine Stop)
G02	Circular Interpolation in clockwise direction.	G17	XY Plane	M30	End of Program (Machine Stop) and Reset or Rewind of tape
G03	Circular Interpolation in anti-clockwise direction.	G18	XZ Plane	M03	Spindle Starts rotating in Counter Clockwise Direction
		G19	YZ Plane		
G90	Absolute Mode of programming. (Default Accepted Code)	G04	Dwell/ Delay	M04	Spindle Starts rotating in Clockwise Direction
		G05	Hold (Turn on Console Switch for resuming)		
G91	Incremental Mode of programming.			M05	Spindle Stop
				M06	Tool Change (Automatic Magazine used)
G70	English Programming (Inch).			M04	Spindle Starts rotating in Clockwise Direction
G71	Metric Programming (mm). (Default Accepted Code)			M07	Coolant Pump ON-I
				M08	Coolant Pump ON-II
				M09	Coolant Pump OFF
				M10	Automatic Clamping
				M11	De-Clamping

DNC (Direct Numerical Control): (BTR- Behind the Tape Reader)

	Host Computer		**Bulk Memory**	**LAN**
NC-I	**NC-II**	**NC-III**	**NC-IV**	

- Single Tap can be stored in host computer's bulk memory and it directs multiple NC machines (256 NC's).
- NC machines are hard wire connected CPUs. (NC's don't have memory and own processing unit/ Brain)

DNC (Distributive Numerical Control):

	Host Computer		**Bulk Memory**	**LAN**
CNC-I	**CNC-II**	**CNC-III**	**CNC-IV**	

- Host computer send different program to each and every CNC to execute.
- CNC is not hard wire connected CPUs. (It has memory and own processing unit/ Brain)

NC=> DNC => CNC (1967) => Distributive

TRANSFORMATION COMMANDS IN COMPUTER GRAPHICS	
TRANSLATION	**SCALING/ ZOOM**
$[P'] = [T] + [P], Where\ [T]\ Translation\ Vector$ $\begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix} = \begin{bmatrix} T_x \\ T_y \\ T_z \\ 0 \end{bmatrix} + \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$	$[P'] = [S][P], Where\ [S]\ Scaling\ Factor\ matrix$ $\begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$
ROTATION	**REFLECTION**
$[P'] = [R][P], Where\ [R]\ Rotation\ Vector$ $For\ CCW, \theta = +ve, For\ CW, \theta = -ve$ $\begin{bmatrix} X' \\ Y' \\ Z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \\ 1 \end{bmatrix}$	Reflection about X axis: $\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix}$ Reflection about Y axis: $\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix}$ Reflection about Origin: $\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix}$ Reflection about X=Y Line: $\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix}$

Type of Scaling: 1. Uniform Scaling: $S_x = S_y = S_z$, Shape is not changing. 2. Differential Scaling: $S_x \neq S_y \neq S_z$, Shape is not changing.	Scale (x:y) = x is actual dimension, y is dimension on paper Scale Factor = y/x