CHAPTER 2

FUNDAMENTALS OF MACHINE TOOLS AND OPERATIONS

INTRODUCTION –

A product or part can be manufactured by various processes like casting, forging, machining etc. Machining is an operation that can be carried out manually or by machine, which involves removal of excess material from the raw material so as to get the required shape and size. So any machine involved in metal cutting is known as a 'Machine tools' and the process is called 'Machining'.

"**A machine tool** may be defined as a power driven machine to produce a product by removing the excess material using a cutting tool". The excess material removed is called as chips.

Some of the important machine tools are

Lathe,

Drilling machine,

Milling machine,

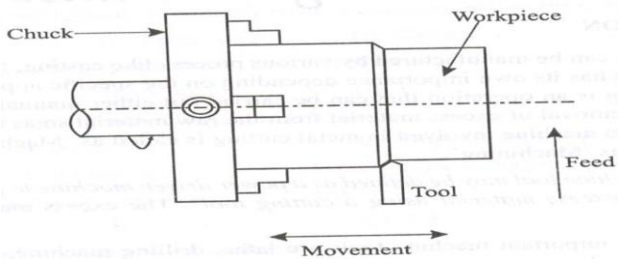
Grinding machine,

Shaper, etc.

LATHE: - Lathe Machine is a Machine Tool which is used to remove the excess material using a cutting tool called as single point cutting tool.

In Lathe machine a stationary Single point cutting tool is fed against the rotating work piece to remove excess material.

PRINCIPLE OF WORKING



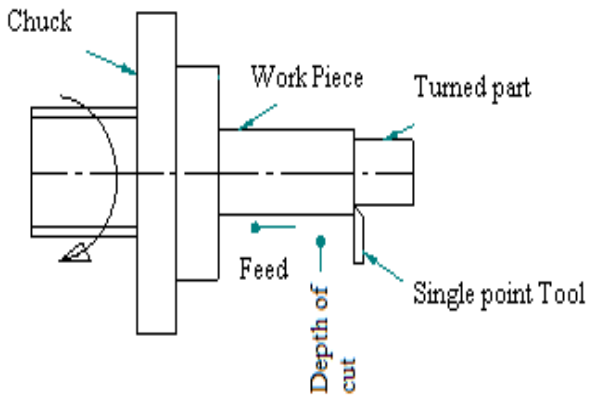
A lathe, basically a turning machine works on the principle that a cutting tool can remove material in the form of chips from the rotating work pieces to produce circular objects This is accomplished in a lathe which holds the work pieces rigidly and rotates them at high speeds while a cutting tool is moved against it.

LATHE OPERATIONS:

1. Turning
2. Facing
3. Knurling
4. Thread cutting
5. Taper Turning

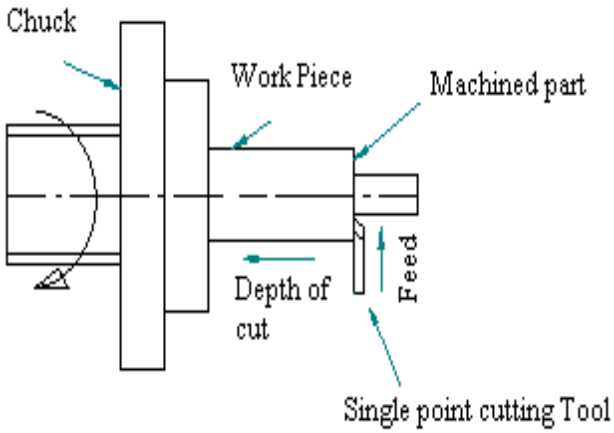
TURNING:

- Turning produces cylindrical objects. Work piece is held in chuck and is rotated at required speed.
- A stationary Single point cutting tool is fed against a rotating work piece to remove excess material.
- Depth of cut is given by moving cutting tool perpendicular to the lathe axis and feed is given by moving tool parallel to the lathe axis.



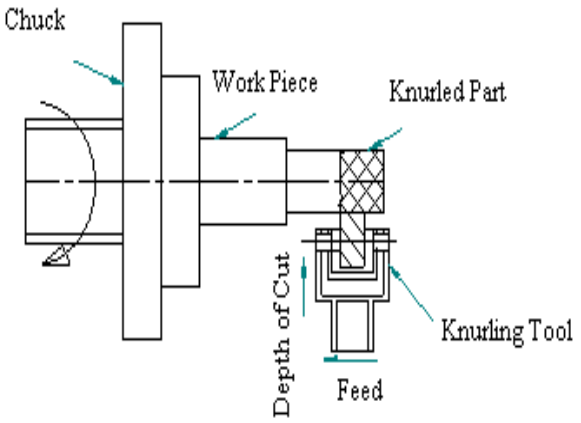
FACING:

- Facing produces flat objects Work piece is held in chuck and is rotated at required speed.
- A stationary Single point cutting tool is fed against a rotating work piece to remove excess material.
- Depth of cut is given by moving cutting tool parallel to the lathe axis and feed is given by moving tool perpendicular to the lathe axis.



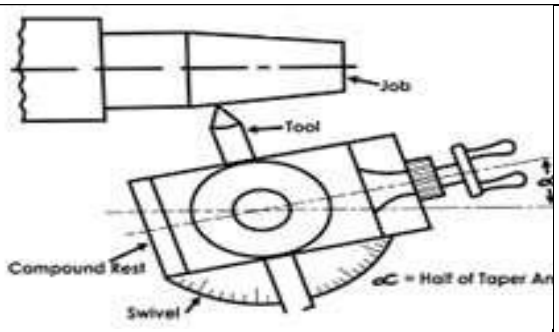
KNURLING:

- Knurling produces serrations on the objects Knurling is done for gripping purpose Work piece is held in chuck and is rotated at required speed.
- A Knurling tool is fed against a rotating work piece to remove excess material.
- Depth of cut is given by moving cutting tool perpendicular to the lathe axis and feed is given by moving tool parallel to the lathe axis.

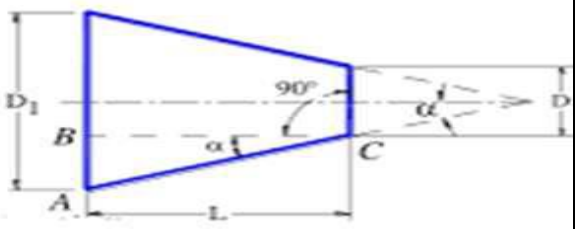


TAPER TURNING:

- In this method the work piece is in line with the lathe axis and the tool is moved inclined to produce the required taper.
- The compound rest which supports the tool post is swiveled to the required angle and locked.
- The required tool movement is given by the compound slide.



Taper Angle Calculation:



Taper: $\tan\alpha = \frac{D1-D2}{2L}$

DRILLING

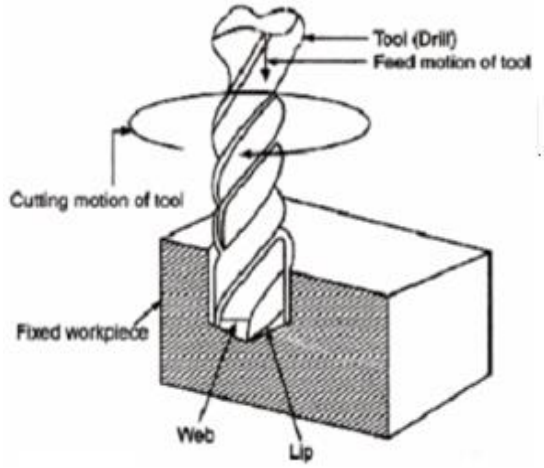
INTRODUCTION

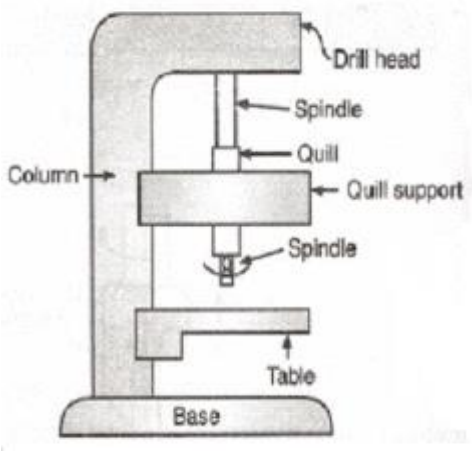
The drilling machine or drill press is one of the most common and useful machine employed in industry for producing forming and finishing holes in a workpiece. The unit essentially consists of:

1. A spindle which turns the tool (called drill) which can be advanced in the workpiece either automatically or by hand.
2. A work table which holds the workpiece rigidly in position.

WORKING PRINCIPLE

The rotating edge of the drill exerts a large force on the workpiece and the hole is generated. The removal of metal in a drilling operation is by shearing and extrusion.





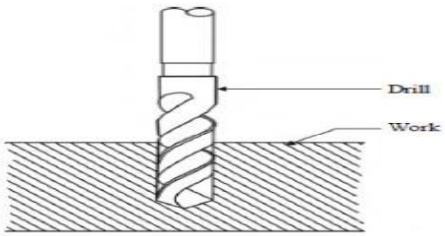
DRILLING MACHINE OPERATIONS

Though drilling is the primary operation performed in a drilling machine, a number of similar operations are also performed on holes using different tools. The different operations that can be

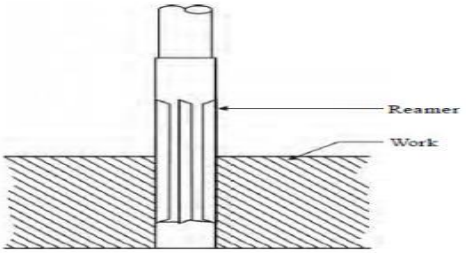
Performed in a drilling machine are:

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Countersinking

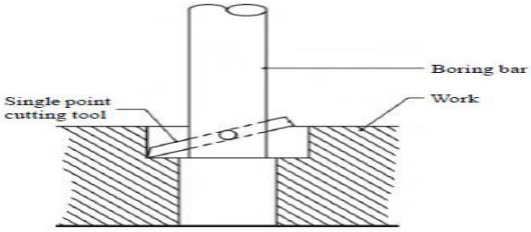
1. Drilling: The operation of drilling consists of producing a hole in an object by forcing a rotating drill against it. The same result is carried out in some machines by holding the drill stationary and rotating the work as on the lathe.



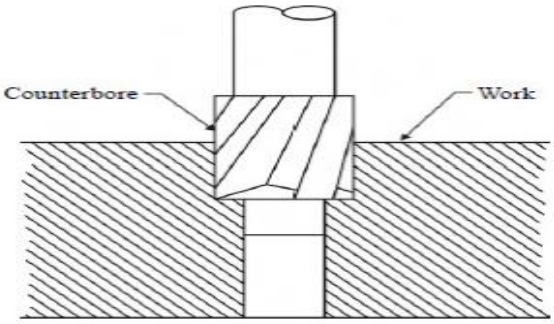
2. Reaming: It is the operation of enlarging a machined hole to proper size to a smooth finish. A reamer is an accurate tool and is not designed to remove much metal.



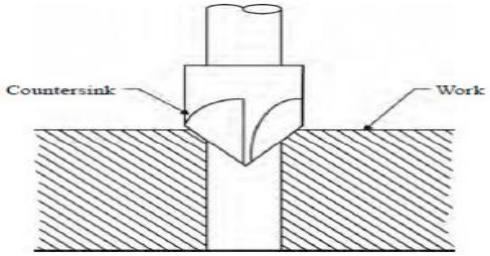
3. Boring: It is the operation of enlarging a hole that has already been drilled or bored with a single point tool. It also rectifies the error of drilling, if any.



4. Counter boring: A Counter bore is a multi-tooth cutting tool used for enlarging the top of the previously machined hole. It has three or four cutting teeth. The flutes on them may be straight or helical. Straight fluted tools are used for machining softer materials like brass and aluminum and for short depth of cut. Helical fluted counter bores are used for longer holes.



5. Countersinking: A countersink has cutting edges on its conical surfaces. It has a similar construction of a counter bore except for the angle of the cutting edges. The angle of countersinks will generally be 60°, 82° or 90°. It is used for enlarging the top of the holes conically.



MILLING MACHINES

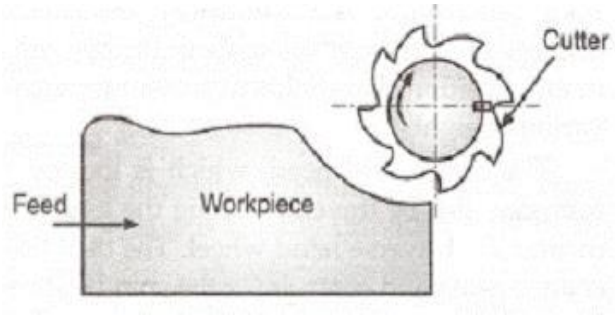
INTRODUCTION:

Milling is the cutting operation that removes metal by feeding the work against a rotating, cutter having single or multiple cutting edges. Flat or curved surfaces of many shapes can be machined by milling with good finish and accuracy. A milling machine may also be used for drilling, slotting, making a circular profile and gear cutting by having suitable attachments.

The milling machine is a type of machine tool which removes the material from the work piece by feeding the work past a rotating multipoint cutter**.**

WORKING PRINCIPLE:

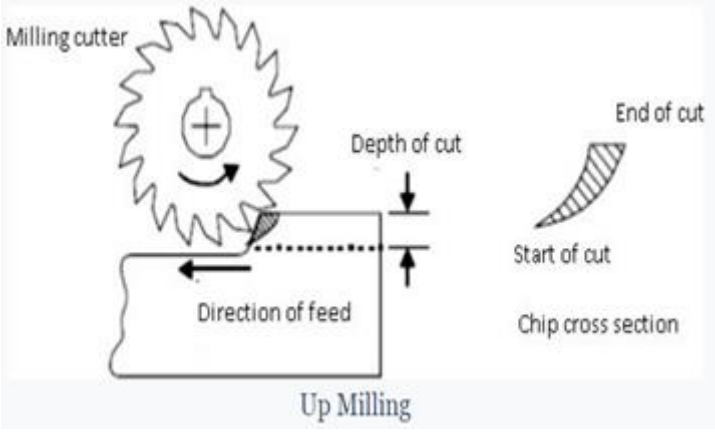
The work piece is rigidly clamped on the worktable of the machine. And rigidly clamped work piece is fed against the cutter which is mounted on a spindle or arbor and revolves at high speed. As the work piece advances, the cutter teeth remove the metal from the surface of work piece and the desired shape is produced.



Up Milling:

Up milling is also called as conventional milling.

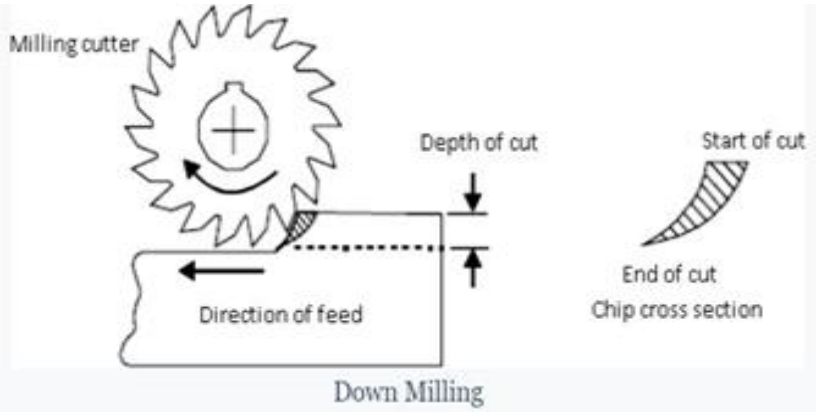
In this method, the cutter rotates in a direction opposite to that in which the work pieces.



Down Milling:

Down milling is also called as climb milling.

In this method, the cutter rotates in the same direction of fed.



Differences between up milling and down milling

Sl. No	Up Milling	Down Milling
1	In up milling the cutter rotates in opposite direction of feed	In down milling the cutter rotates in the same direction of feed
2	Called as conventional milling method	Called as non-conventional or climb milling method
3	Chips removal starts with minimum thickness and ends with maximum thickness	Chips removal starts with maximum thickness and ends with minimum thickness
4	Cutting action tries to lift the job, hence more clamping force is required.	Cutting action tries to press the job, hence less clamping force is required.
5	The cutting chips carried in upward direction	The cutting chips are carried downward direction
6	There is massive friction between the cutter and work piece which results in generating a large amount of heat.	There is less friction between the cutter and work piece which results in generating a less amount of heat.
7	This is a safe operation because it has no tendency to drag the work piece into the cutter.	This is not a safe operation because it has the tendency to drag the work piece into the cutter.
8	used for machining of casting and forging	used for small work such as slot cutting, milling grooves, slitting. etc.

MILLING OPERATIONS

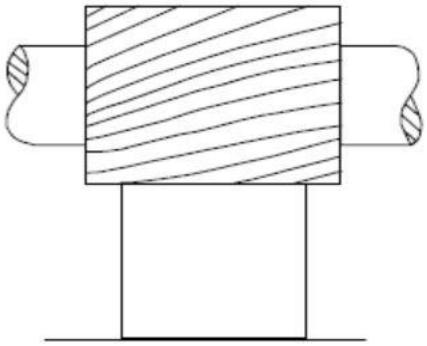
As we know that milling can perform various operations to convert the work piece into desire shape. It is a very useful machine and mostly used in die making industries. The most popular operation done on milling machine is described below.

1. Plain or slab milling
2. Slot milling

Plain milling or slab milling:

Fig. illustrates the plain and slab milling operation. It is a method of producing a plain, flat, horizontal surface parallel to the axis of rotation of the cutter.

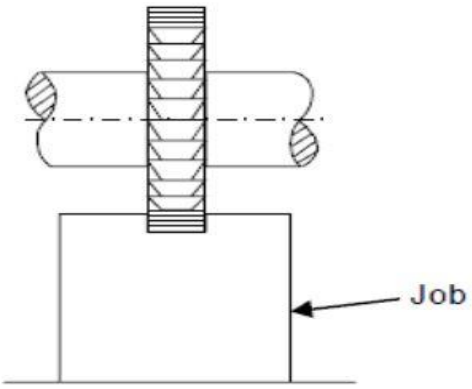
This is also called slab milling. This operation produces flat surfaces on the workpiece. Feed and depth of cut are selected; the rotating milling cutter is moved from one end of the workpiece to another end to complete the one pairs of plain milling operation.

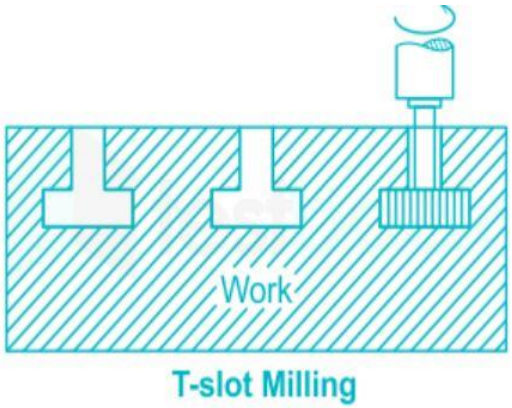


Plain Milling Or Slab Milling Operation

Slot milling:

The operation of producing keyways, grooves, slots of varying shapes and sizes is called slot milling operation. Slot milling operation can use any type of milling cutter like plain milling cutter, metal slitting saw, or side milling cutter. Selection of a cutter depends upon type and size of slot or groove to be produced.





COMPUTER NUMERICAL CONTROL (CNC):

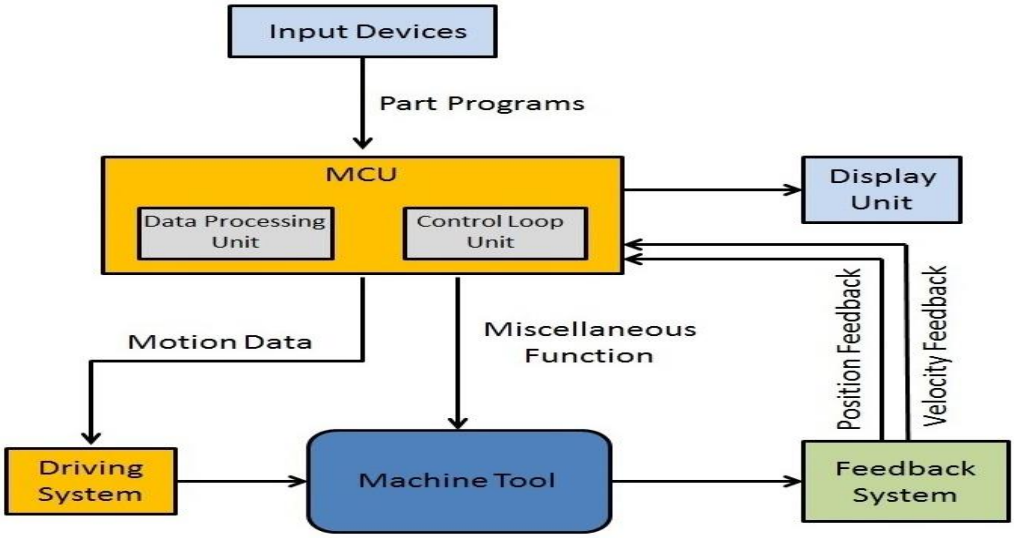
Definition: When computers are used to control a NC machine tool, then the machine is called CNC machine.

In other words, the use of computers to control machine tools like lathe, Mills, shapers, slotters, etc. is called CNC machine.

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

Computer Numerical Control has evolved during the rapid improvements of the computer technology. Today's CNC Controller has latest features like high speeds of operation, large memories, bus architectures, improved servos, etc. CNC Technology has powered the Machine Tool industry today.

COMPONENTS OF A CNC SYSTEM:



A CNC System consists of the following elements:

I. Input Device

2. MCU or Machine Control Unit

3. Machine Tool

4, Driving System

5. Feedback devices

6. Display Unit

(i) Input Devices: These are the devices which are used to input the part program in the CNC machine. There are three commonly used input devices and these are punch tape reader, magnetic tape reader and computer via RS-232-C communication.

(ii) Machine Control Unit (MCU): It is the heart of the CNC machine. It performs all the controlling action of the CNC machine, the various functions performed by the MCU are

- It reads the coded instructions fed into it.
- It decodes the coded instruction.
- It implements interpolation (linear, circular and helical) to generate axis motion commands.
- It feeds the axis motion commands to the amplifier circuits for driving the axis mechanisms.
- It receives the feedback signals of position and speed for each drive axis.
- It implements the auxiliary control functions such as coolant or spindle on/off and tool change.

(iii) Machine Tool: A CNC machine tool always has a slide table and a spindle to control the position and speed. The machine table is controlled in X and Y axis direction and the spindle is controlled in the Z axis direction.

(iv) Driving System: The driving system of a CNC machine consists of amplifier circuits, drive motors and ball lead screw. The MCU feeds the signals (i.e. of position and speed) of each axis to the amplifier circuits. The control signals are than augmented (increased) to actuate the drive motors. And the actuated drive motors rotate the ball lead screw to position the machine table.

(v) Feedback System: This system consists of transducers that act as sensors. It is also called a measuring system. It contains position and speed transducers that continuously monitor the position and speed of the cutting tool located at any instant. The MCU receives the signals from these transducers and it uses the difference between the reference signals and feedback signals to generate the control signals for correcting the position and speed errors.

(vi) Display Unit: A monitor is used to display the programs, commands and other useful data of CNC machine.

WORKING OF CNC MACHINE:

- First, the part program is inserted into the MCU of the CNC.
- In MCU all the data process takes place and according to the program prepared, it prepares all the motion commands and sends it to the driving system.
- The drive system works as the motion commands sent by the MCU. The drive system controls the motion and velocity of the machine tool.
- The feedback system records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU.
- In MCU, the feedback signals are compared with the reference signals and if there are errors, it corrects it and sends new signals to the machine tool for the right operation to happen.
- A display unit is used to see all the commands, programs and other important data. It acts as the eye of the machine.

ADVANTAGES

1. Machining is accurate and have very high precision
2. Time taken to perform a job is very less
3. They are versatile
4. Reliable
5. Safe to operate
6. Number of operators required to operate a machine are reduced
7. No possibility of human error
8. Even very complex designs can also be made
9. Low maintenance required
10. Uniformity in designs
11. They could run for all 24 hours a day

DISADVANTAGES

1. They are costly.
2. Trained operator is required to operate the machine.
3. In case of breakdown a highly skilled professional is required to solve the problem.
4. Reduction in manual labour can lead to unemployment.
5. Its installation cost is high.

Applications of CNC machines

1. Metal removal industries
2. Material fabrication industries
3. For non-conventional machining industries where the machining task is difficult to perform manually

3D PRINTING:

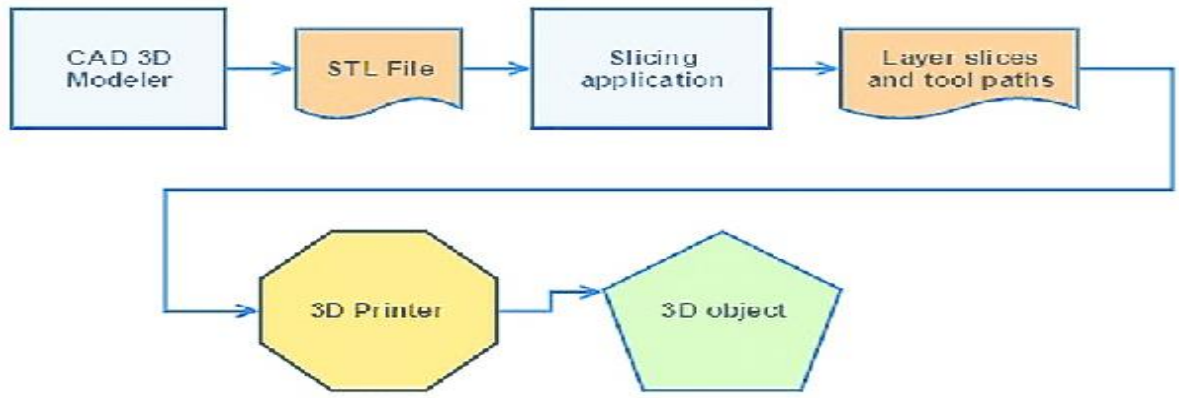
3D printing is also known as 'Additive manufacturing'

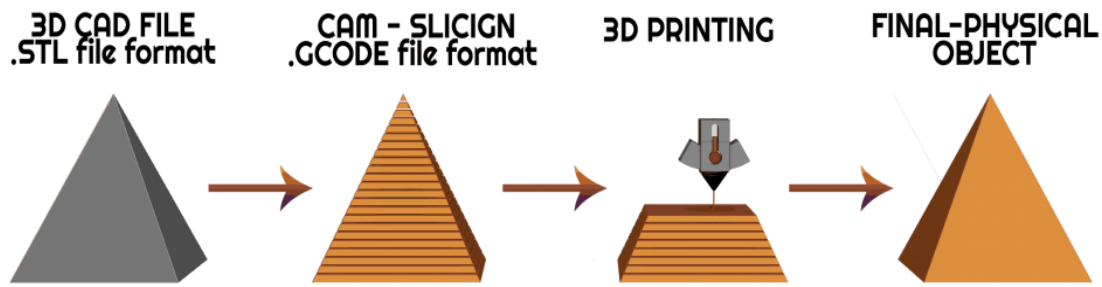
It is a method of manufacturing, due to the fact that instead of removing material to create a part, the process adds material in successive patterns to create the desired shape.

Main areas of use:

- Prototyping
- Specialized parts – aerospace, military, biomedical engineering, dental
- Hobbies and home use
- Future applications– medical (body parts), buildings and cars

How Does 3D Printing Work?





Depending on the specific print you are planning to do there could be more or fewer steps in your process. But in general, 3D printing involves the following actions:

Step 1: Create or Find a Design

The first step of 3D printing typically starts on a computer. You must create your design using a 3D design software, typically a CAD (computer-aided design) software.

Step 2: Export the STL File

Once you have created or chosen a design, you must either export or download the STL file. The STL file is what stores the information about your conceptual 3D object.

Step 3: Choose Your Materials

Typically, you may have an idea about what kind of material you will use before you print. There are many different 3D printing materials available, and you can choose them based on the properties that you want your object to have.

Step 4: Choose Your Parameters

The next step is then deciding on the different parameters of your object and the printing process. This includes deciding on the size and placement of your print.

Step 5: Create the G-code

You will then import the STL file into a slicing software, like Cura. The slicing software will convert the information from the STL file into a **G-code**, which is a specific code containing exact instructions for the printer.

Step 6: Print

This is when the magic happens! The printer will create the object layer by layer. Depending on the size of your object, your printer, and the materials used, the job can be done in a matter of minutes or over several hours.

Depending on what you want your final product to be or the material you used, there may be additional post-processing steps after printing, like painting, brushing off powder, etc.

ADVANTAGES OF 3D PRINTING:

1. Flexibility: 3D printing enables you to design even complex structures that are impossible to design through traditional printing otherwise. Manufacturers can produce components that generally have complex geometry and are difficult to make. Thus, the concept of **3D printing overcomes** such limitations of traditional printing restrictions easily.

2. Quick Prototyping Solutions: Quick printing solutions are one of the significant **benefits of additive manufacturing**. Aerospace, Fashion, Automotive, Architecture, and healthcare industries use the technology to build prototypes that are quick to design and cost-effective.

3. 3D Printed Components are durable & Lightweight: Metals and plastic materials are generally used to manufacture **3D printed components**. Plastics are lighter than their metal counterparts. Plastic parts are helpful in the aerospace and aviation industries as they don't put much weight on the aircraft.

4. Minimal Waste: The only thing that a 3D printer requires is the material to print. Since traditional designing methods incorporate different materials and machinery, there is little wastage of resources and non-recyclable materials in 3D printing.

5. Environment-Friendly: Environment-friendliness is among the key advantages of 3D printing. As this technology cuts the amount of material wastage with no emissions and carbon footprints, it can be an eco-friendly option. The environmental **benefits of 3D printing** extend in terms of improved fuel efficiency from using lightweight parts.

DISADVANTAGES OF 3D PRINTING:

1. Cost: The newer the technology, the higher is the cost. The materials and equipment used in 3D printing is expensive in comparison to the traditional manufacturing material.

2. Limited Materials: Since the printed material used in Aviation and aerospace industries is of high quality, companies can't compromise with quality. However, the availability of quality raw material is one of the significant **drawbacks of 3D printing**. This is because not all the metals or plastics can be temperature controlled to allow 3D printing; only rare metals and plastics can be used.

3. Size Limitations of 3D Printing: Printers have small print chambers which limit the size of parts to be printed. As a result, you can print small-sized components, which is one of the most significant **limitations of 3D printing technology**. Bigger components will need to be printed in separate parts and joined together once printed. This not only increases costs and time but also makes the printing process complicated.

4. Reduction in Manufacturing Jobs: The things that could be done through manual labour are done using 3D printers. Reduced jobs in the manufacturing and designing sectors are concerning disadvantages of 3D printing technology. Since most of the production is automated, the production is handled by computers.

5. Prohibited Components and Pirated Products: Since an automated 3D printer awaits user's commands, it's easy to create illegal or prohibited components such as Guns, knives, explosives. Theoretically, 3D printing technology can print everything. If it's so, this technology is open access for people to break laws for self-interest.

APPLICATIONS:

1. Aerospace/Aviation
2. Automotive
3. Medical/healthcare
4. Jewellery
5. Art/sculpture
6. Fashion
7. Architecture
8. Food
9. construction