Introduction to Manufacturing Trades

By

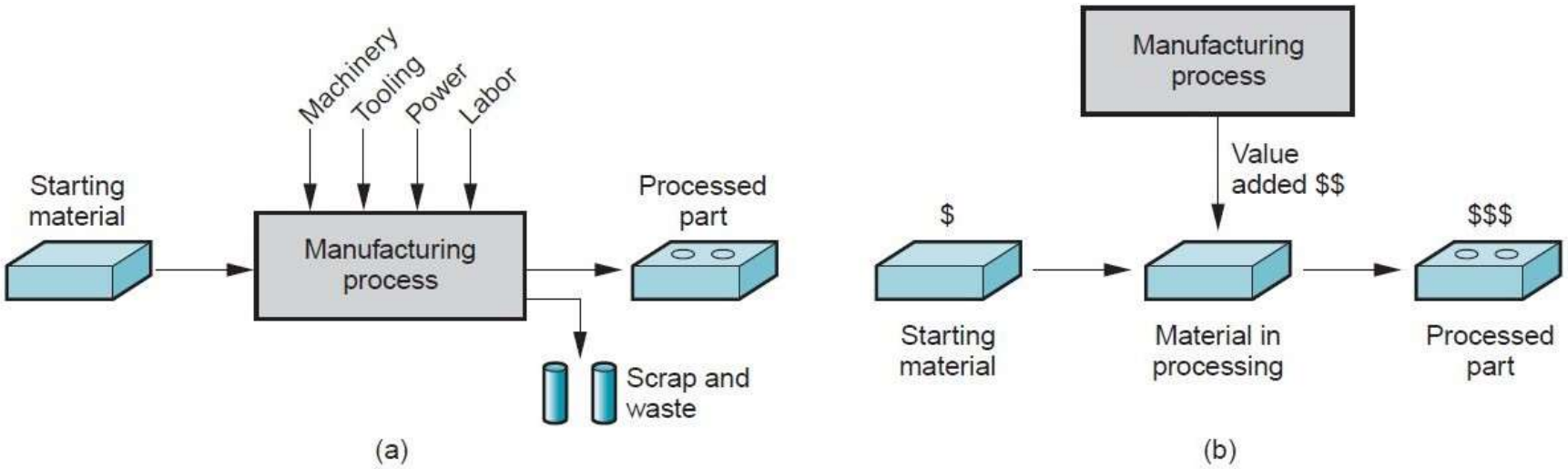
Rakesh Singhai

For DIP Course ES115

Why this lecture

- There are 8 trades to be learnt.
- You learn by doing.
- Since you are learning only 2 trades, due to time constraint, this is an attempt to familiarize you with all the trades.
- If you love to learn more, figure out a way.

Definition of manufacturing



Manufactured products

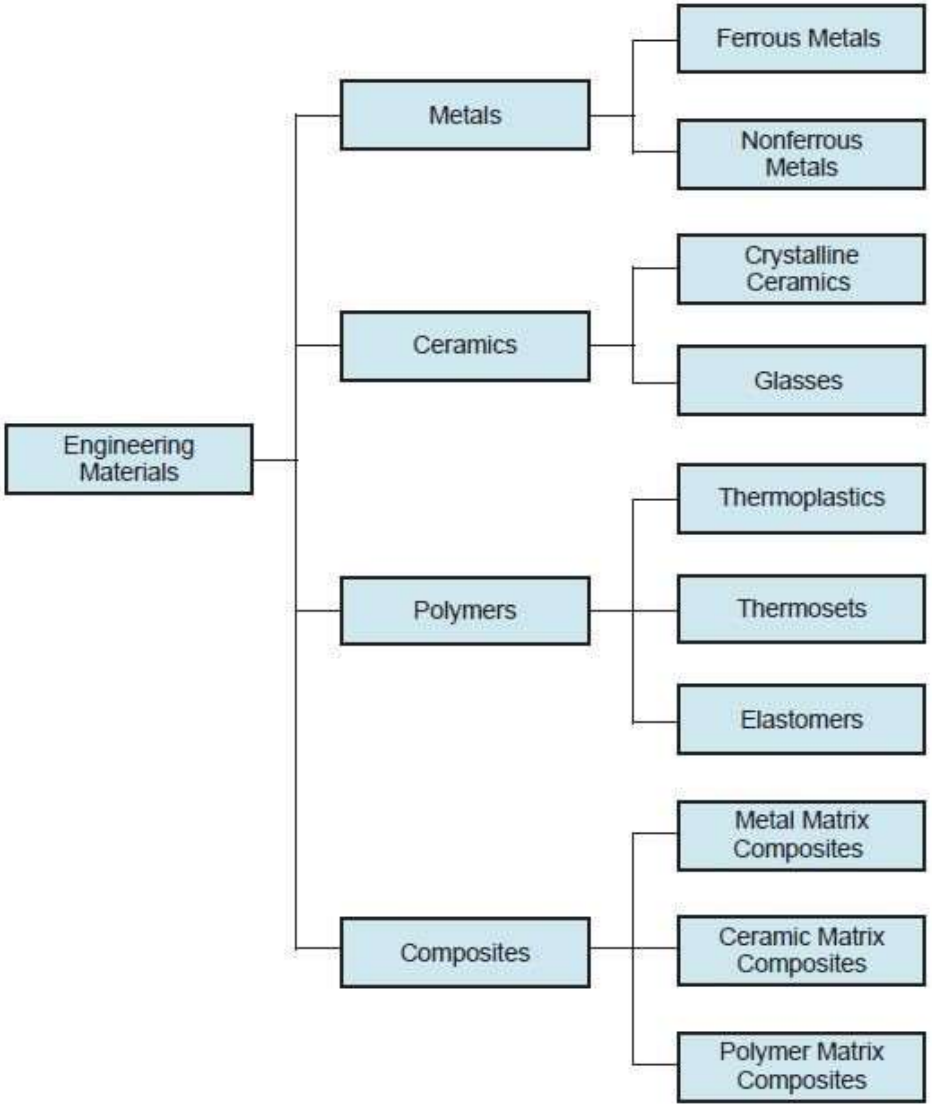
TABLE 1.1 Products representing various technologies, most of which affect nearly everyone.

Athletic shoes	Fax machine	One-piece molded plastic patio chair
Automatic teller machine	Flat-screen high-definition television	Optical scanner
Automatic dishwasher	Hand-held electronic calculator	Personal computer (PC)
Ballpoint pen	High density PC diskette	Photocopying machine
Cell phone	Home security system	Pull-tab beverage cans
Compact disc (CD)	Hybrid gas-electric automobile	Quartz crystal wrist watch
Compact disc player	Industrial robot	Self-propelled mulching lawnmower
Compact fluorescent light bulb	Ink-jet color printer	Supersonic aircraft
Contact lenses	Integrated circuit	Tennis racket of composite materials
Digital camera	Magnetic resonance imaging	Video games
Digital video disc (DVD)	(MRI) machine for medical diagnosis	Washing machine and dryer
Digital video disc player	Microwave oven	

Manufactured products

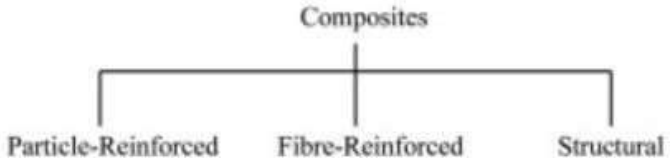
- Consumer goods
- Capital goods- Also used by service industry
- Materials, components, supplies

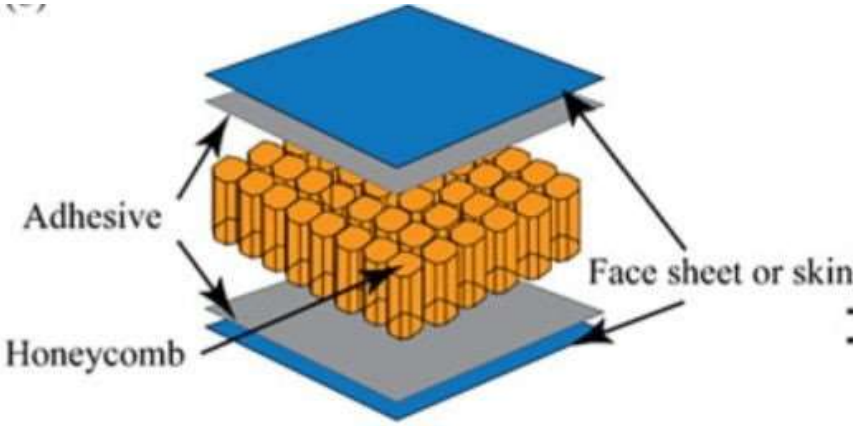
Materials


Engineering Materials
Metals
Ferrous Metals
Nonferrous Metals
Ceramics
Crystalline Ceramics
Glasses
Polymers
Thermoplastics
Thermosets
Elastomers
Composites
Metal Matrix Composites
Ceramic Matrix Composites
Polymer Matrix Composites

Composites

Composites do not really constitute a separate category of materials; they are mixtures of the other three types. A ***composite*** is a material consisting of two or more phases that are processed separately and then bonded together to achieve properties superior to those of its constituents. The term ***phase*** refers to a homogeneous mass of material, such as an aggregation of grains of identical unit cell structure in a solid metal. The usual structure of a composite consists of particles or fibers of one phase mixed in a second phase, called the ***matrix.***





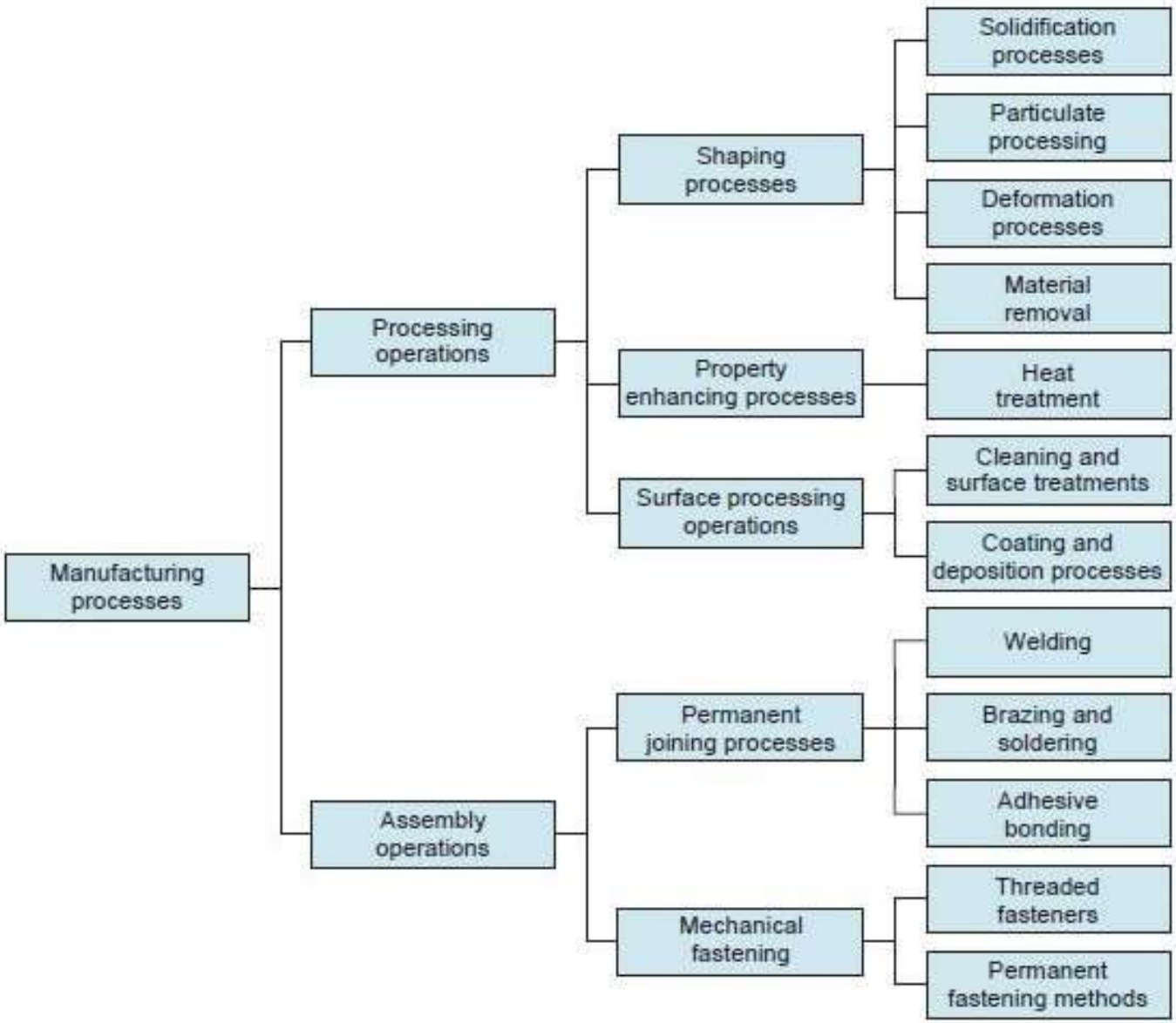
Manufacturing capability

- Materials- Can you handle this matl.
- Processes- Do you understand the process
- System- Do you have complete system to manufacture

- Technological capability :e.g. Can you achieve tolerance reqd.
- Size capability- e.g. Is your machine large enough to handle the requirement
- Production capacity- e.g. Can you produce the qty required in given time

Manufacturing processes

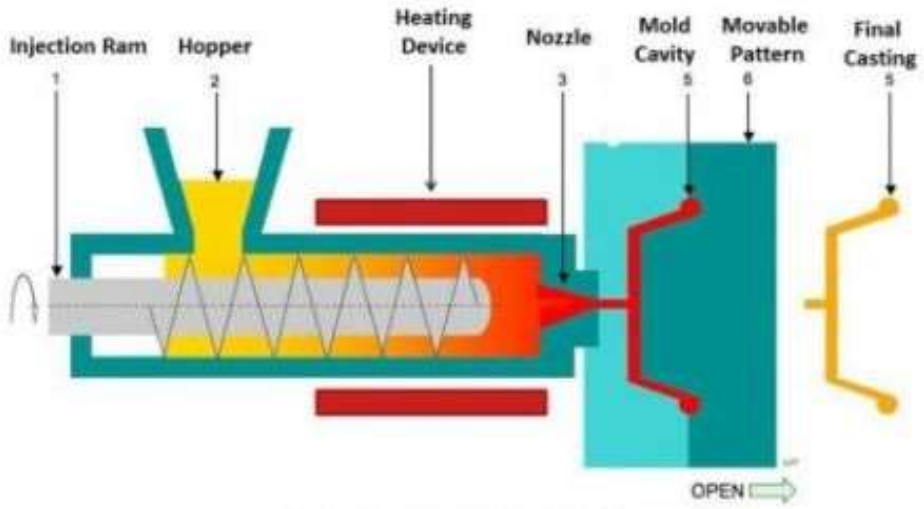
- Processing operations
- Assembly operations

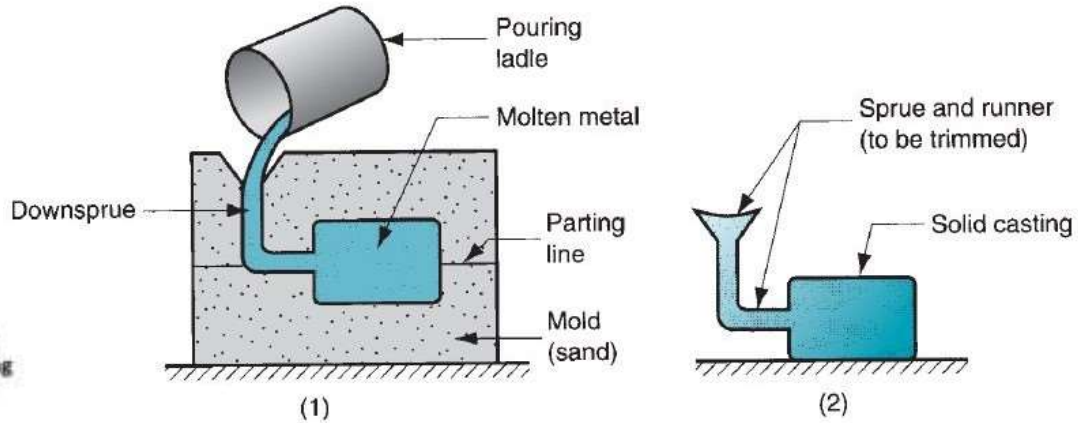

Manufacturing processes
Processing operations
Shaping processes
Solidification processes
Particulate processing
Deformation processes
Material removal
Property enhancing processes
Heat treatment
Surface processing operations
Cleaning and surface treatments
Coating and deposition processes
Assembly operations
Permanent joining processes
Welding
Brazing and soldering
Adhesive bonding
Mechanical fastening
Threaded fasteners
Permanent fastening methods

Multiplicity of processes

- Shaping processes- Heat, mechanical force or combo
- 1. Solidification processes- liquid, semi liquid to shape
- 2.Particulate processing- Powder heated into desired geometry
- 3.Deformation processes- Chunk of material reshaped- Forging
- 4. Material removal processes- Material removal to get desired shape

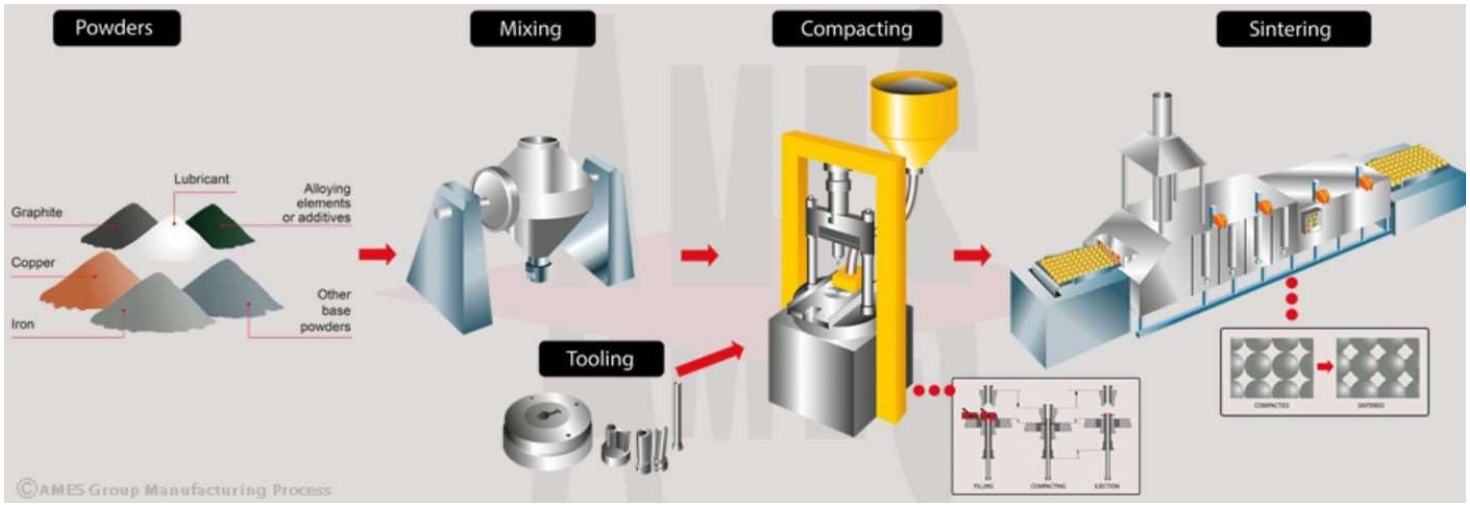
Solidification- Casting & Injection moulding

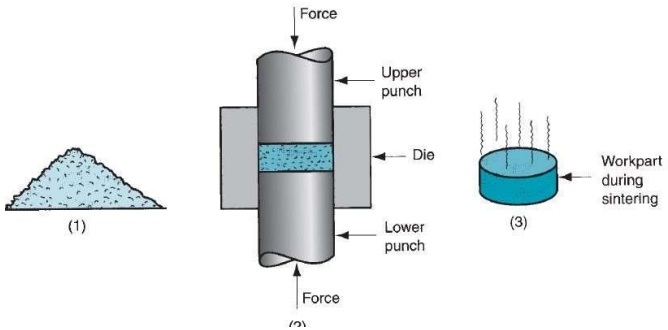




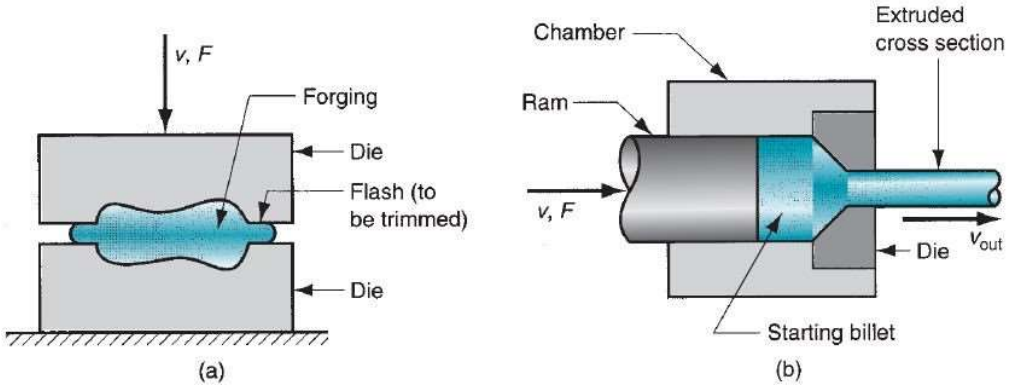
Particulate processing- Sintering

What is the Sintering Process? Sintering is a heat treatment process where loose material is subjected to high temperature and pressure in order to compact it into a solid piece.





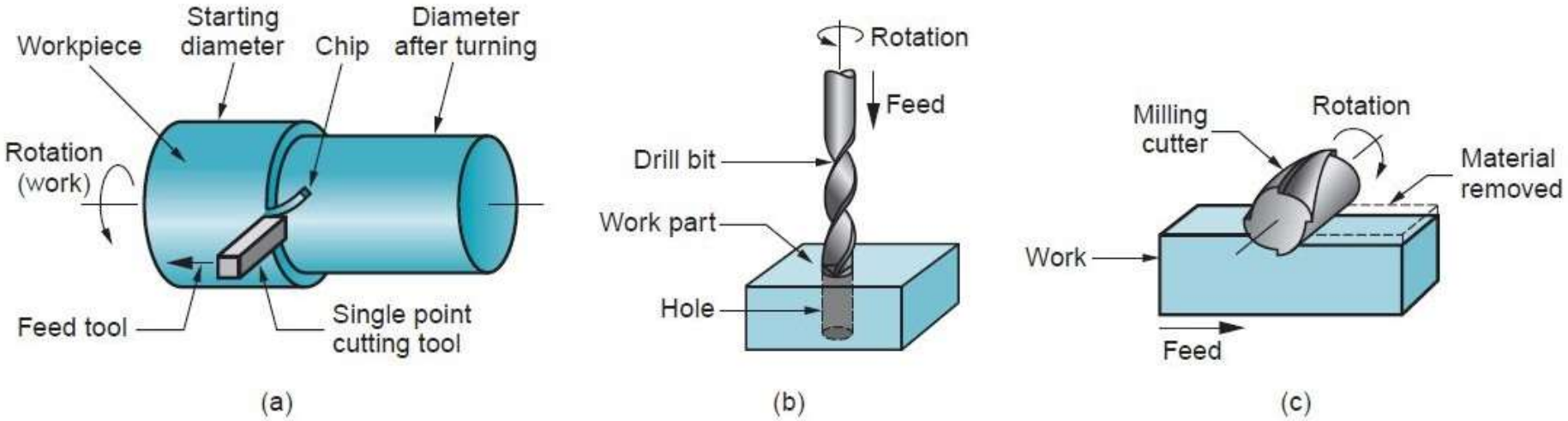
Deformation processes- Forging, extrusion



Forging is a manufacturing process involving the shaping of a metal through hammering, pressing, or rolling. These compressive forces are delivered with a hammer or die. Forging is often categorized according to the temperature at which it is performed—cold, warm, or hot forging. A wide range of metals can be forged.

https://www.youtube.com/watch?v=LXbqWMAl7zI

Material removal processes

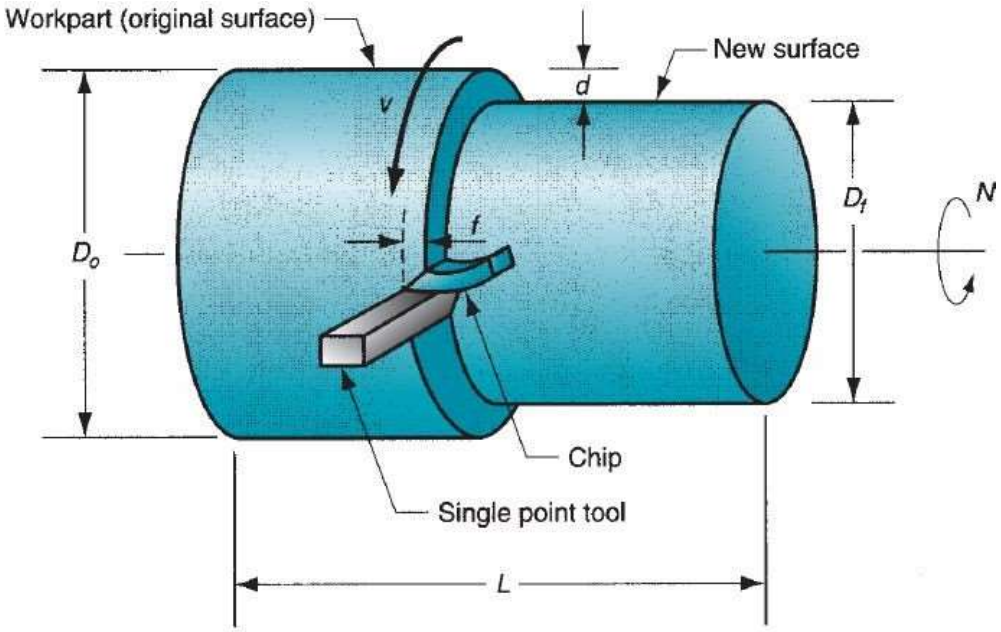


CNC Turning

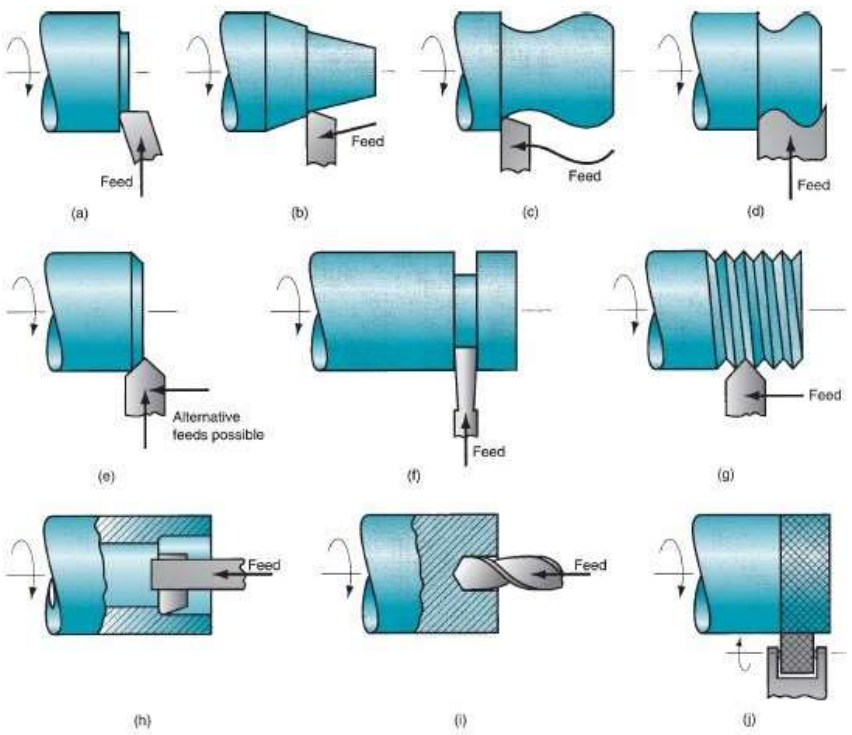
- CNC stands for Computer Numerical Control.
- But let us first understand Turning.

Turning and related operations

Turning is traditionally carried out on a machine tool called a ***lathe,*** which provides power to turn the part at a given rotational speed and to feed the tool at a specified rate and depth of cut.



Related turning operations



(a) ***Facing.*** The tool is fed radially into the rotating work on one end to create a flat surface on the end.

(b) ***Taper turning.*** Instead of feeding the tool parallel to the axis of rotation of the work, the tool is fed at an angle, thus creating a tapered cylinder or conical shape.

(c) ***Contour turning.*** Instead of feeding the tool along a straight line parallel to the axis of rotation as in turning, the tool follows a contour that is other than straight, thus creating a contoured form in the turned part.

(d) ***Form turning.*** In this operation, sometimes called ***forming,*** the tool has a shape that is imparted to the work by plunging the tool radially into the work.

(e) ***Chamfering.*** The cutting edge of the tool is used to cut an angle on the corner of the cylinder, forming what is called a "chamfer."

(f) ***Cutoff.*** The tool is fed radially into the rotating work at some location along its length to cut off the end of the part. This operation is sometimes referred to as ***parting.***

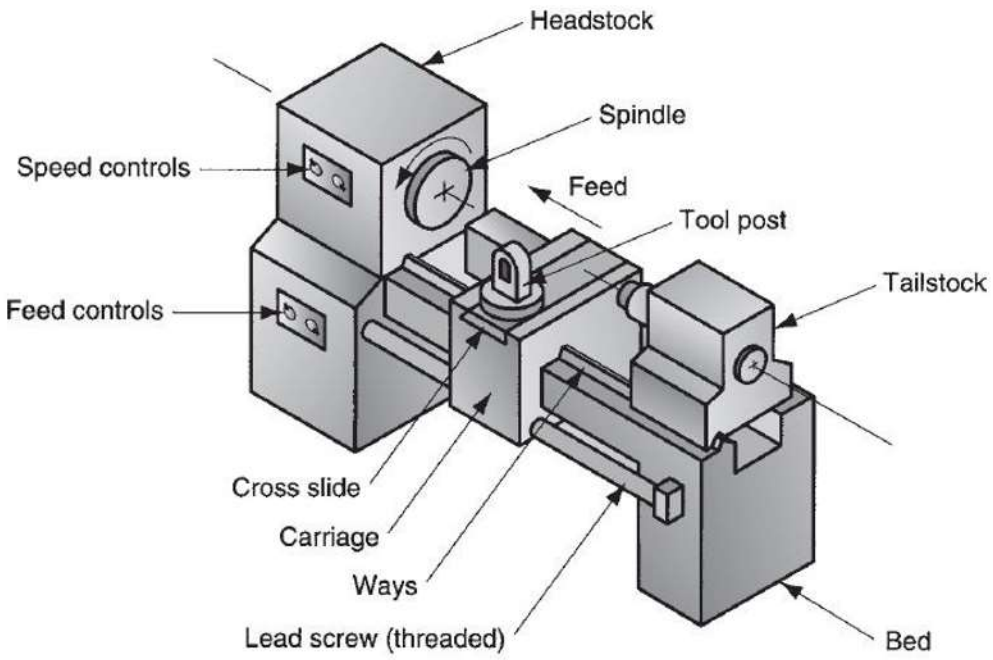
(g) ***Threading.*** A pointed tool is fed linearly across the outside surface of the rotating workpart in a direction parallel to the axis of rotation at a large effective feed rate, thus creating threads in the cylinder. Methods of machining screw threads are discussed in greater detail in Section 22.7.1.

(h) ***Boring.*** A single-point tool is fed linearly, parallel to the axis of rotation, on the inside diameter of an existing hole in the part.

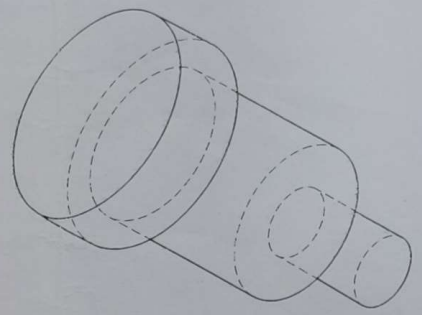
(i) ***Drilling.*** Drilling can be performed on a lathe by feeding the drill into the rotating work along its axis. ***Reaming*** can be performed in a similar way.

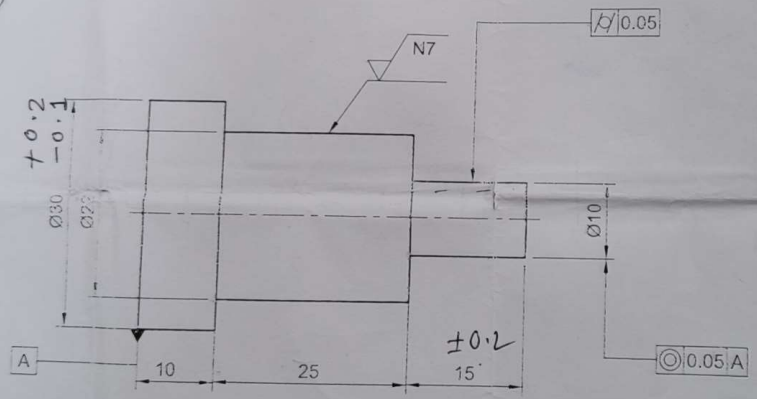
(j) ***Knurling.*** This is not a machining operation because it does not involve cutting of material. Instead, it is a metal forming operation used to produce a regular cross-hatched pattern in the work surface.

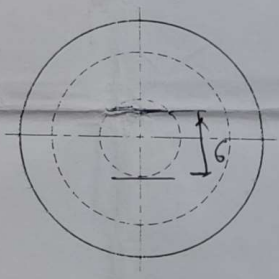
Lathe


Headstock
Spindle
Speed controls
Feed
Tool post
Tailstock
Feed controls
Cross slide
Carriage
Ways
Lead screw (threaded)
Bed

Slant Bed lathes







Symbol	~											
Roughness Values Ra (um)	50	25	12.5	6.3	3.2	1.6	0.8	0.4	0.2	0.1	0.05	0.025
Roughness grade number	N12	N11	N10	N9	N8	N7	N6	N5	N4	N3	N2	N1

Steel		QTY.					----
Open tolerance for dim. not toleranced							Step turning1
0.5 to 6	>6 to 30	>30 to 120	>120 to 315	>315 to 1000	>1000 to 2000	>2000 to 4000	
±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2.0	

Main function of CNC

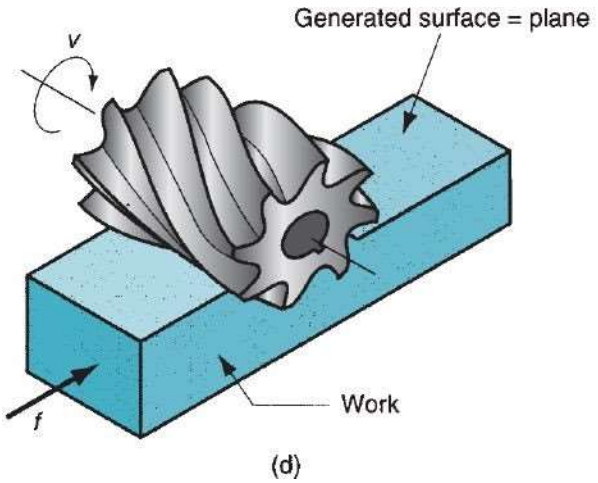
- Main function is axis control.
- Motor rotates a screw. Encoder measures rotation and computer gives command to motor to stop.
- Other functions are secondary. E.g. Motor Speed, direction of rotation. G code and M code are used primarily to program.
- CAM software is used to generate the program from the drawing.

CNC Milling

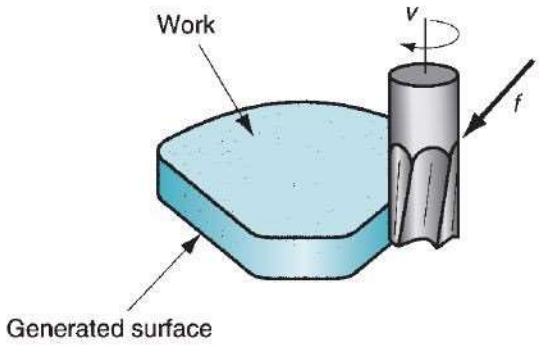
- Let us talk of Milling first.

Milling

- Milling is a machining operation in which a work part is fed past a rotating cylindrical tool with multiple cutting edges.
- The axis of rotation of the cutting tool is perpendicular to the direction of feed.
-
- This orientation between the tool axis and the feed direction is one of the features that distinguishes milling from drilling.



(d)



(e)

Milling Machines

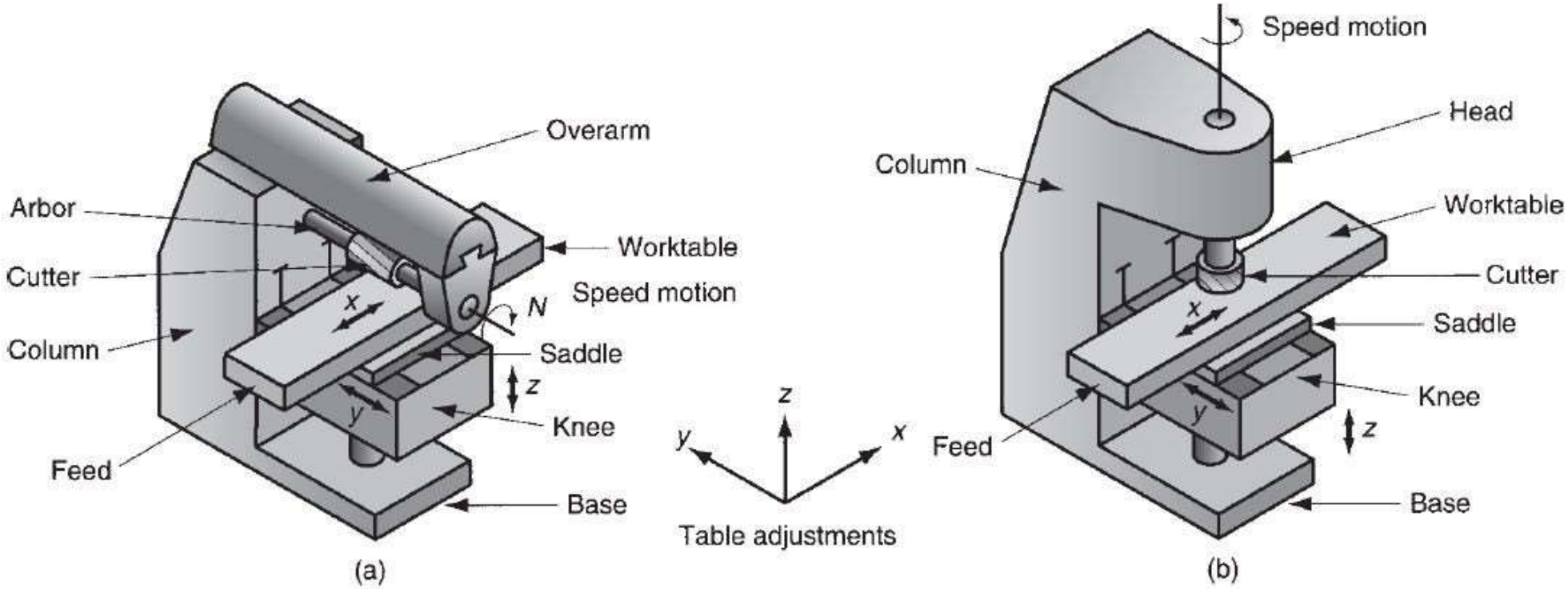
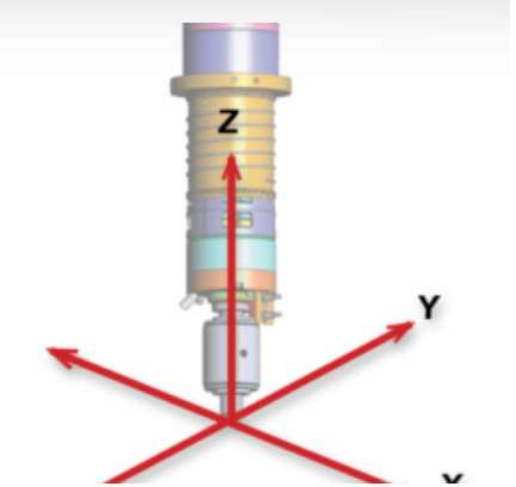


FIGURE 22.23 Two basic types of knee-and-column milling machine: (a) horizontal and (b) vertical.

CNC Milling

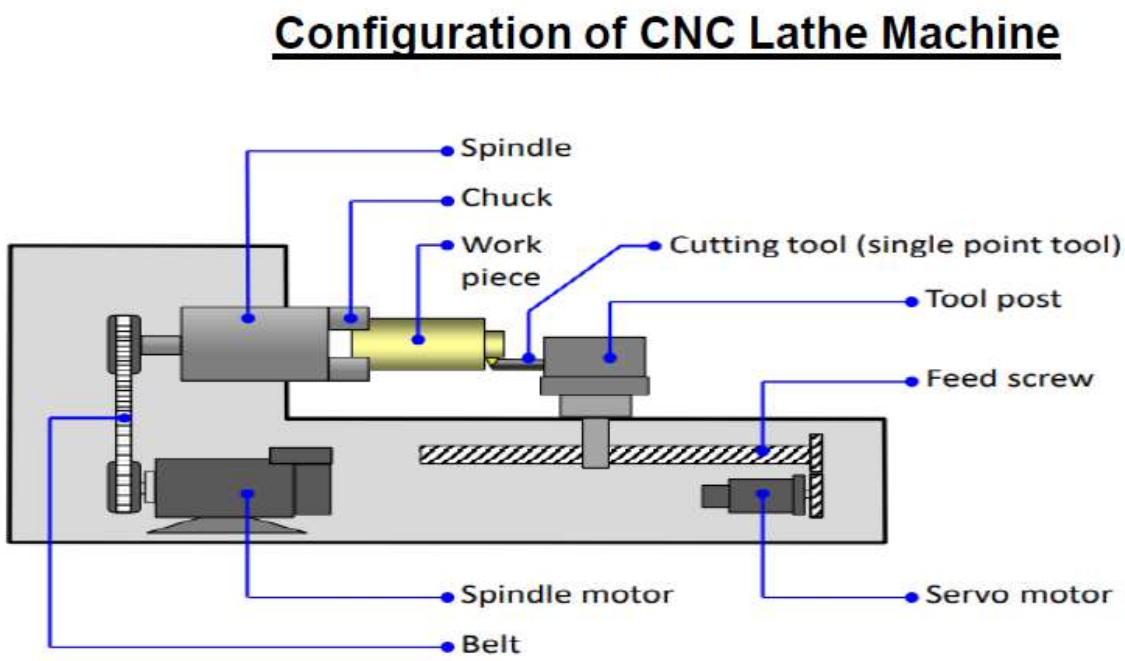
CNC machining

- Machining center needs minimum 3-axis computer control unlike lathe where two axes are adequate.
- This also uses G codes and M codes for programming.
- 5 Axis machines have the cutter rotate in two rotary axes. This helps to machine spherical shaped parts.



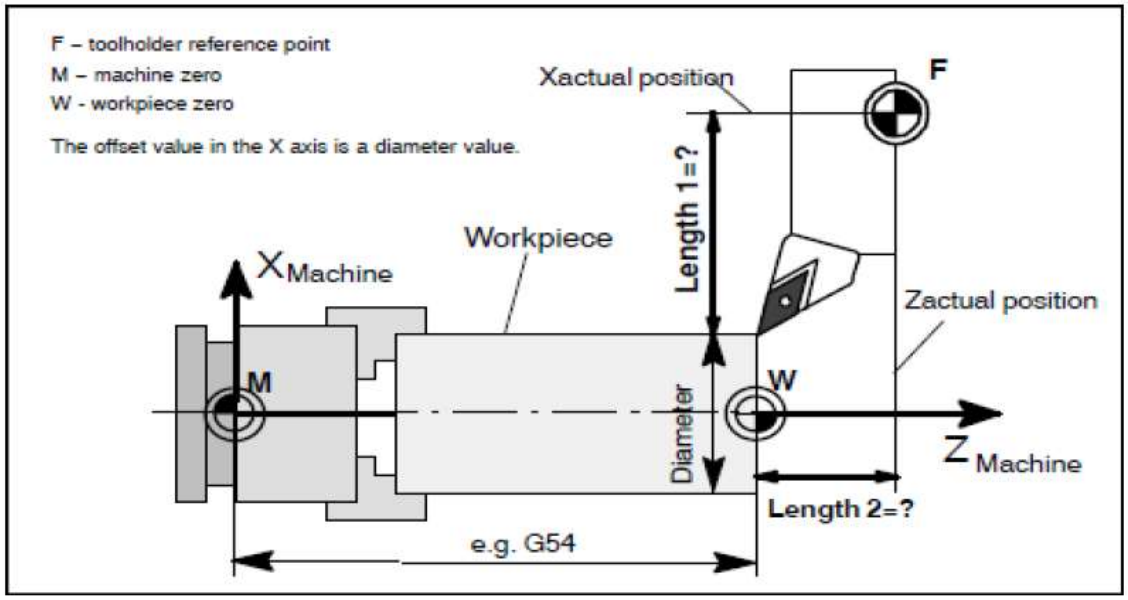
Vertical machining center processing

Wood Working machines



Understanding of offsets

Work Coordinate System



Work offsets are a way of telling your CNC machine where your workpiece is located on the table or the chuck. By using work offsets, you can avoid having to manually measure and enter the coordinates of each feature you want to machine.

G codes

GCodes – Overview

- G00 Positioning (Rapid Feed)
- G01 Linear Interpolation (Cutting Feed)
- G02 Circular Interpolation CW
- G03 Circular Interpolation CCW
- G70 Input in Inches
- G71 Input in Millimeters
- G75 Home Position
- G90 Absolute Command
- G91 Incremental Command
- G94 Feed per Minute
- G95 Feed Per Revolution

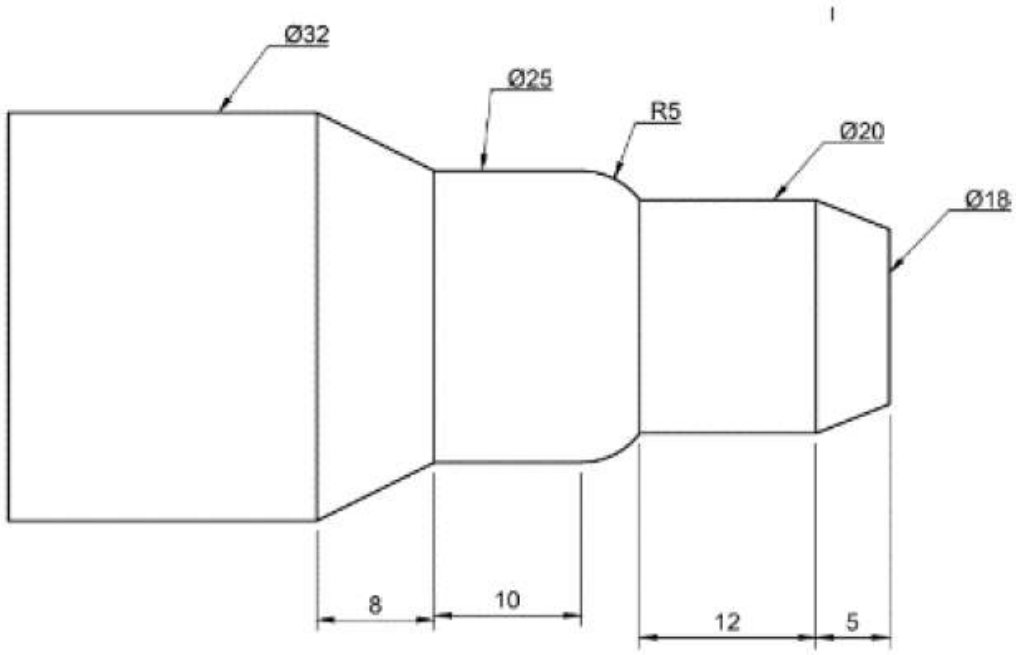
M Code – Overview

- M00 Program Stop
- M01 Optional Stop
- M03 Spindle Forward rotating
- M05 Spindle Stop

Program Writing Method

Example Sub Program:

- G00 X0 Z0
- G01 X18
- G01 X20 Z-5
- G01 Z-17
- G03 X25 Z-22 CR=5
- G01 Z-32
- G01 X32 Z-40
- G01 Z- 60
- M17



CNC lathe for wood working

Safety instructions

- As with all machinery, there are certain hazards involved with the operation and use of your machine.
- Using it with caution will considerably lessen the possibility of personal injury.
- However, if normal safety precautions are overlooked or ignored, personal injury to the operator may result.
- If you have any questions relating to the installation and operation, do not use the equipment until you have contacted TA /lab incharge .

Common terminology

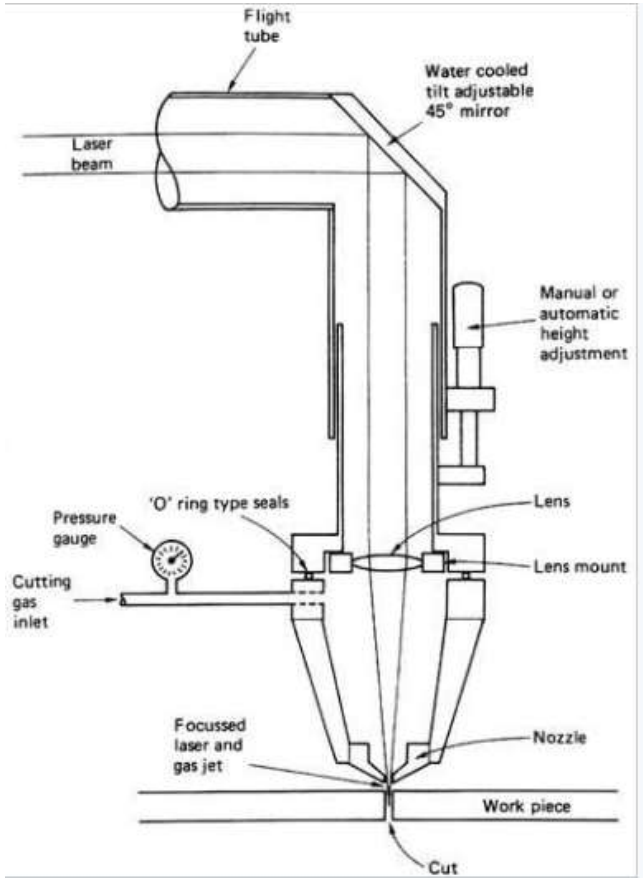
- **DXF file** - Drawing exchange format file that was created as a standard to freely exchange 2- and 3-dimensional drawings between different CAD programs. It basically represents a shape as a wire frame mesh of x, y, and z coordinates (vectors).
- **Encoder** - Typically an optical device that consists of a disk with 100 to 1000 holes on its periphery. The most common is the incremental encoder that has a small LED light source on one side of the disk with a diode detector on the other to allow the disk rotation to be monitored in discrete incremental steps. Hence, a full revolution can be broken up into hundreds or even thousands of position steps.
- **G-Code** - The standard machine tool language around the world. It generally consists of specifying the x, y, or z (and a, b or c) coordinates that the machine is to move to. Such movement can be linear, circular or even special drilling operations. It is the universal language of all modern machine tools (mills, lathes, EDM machines, etc.).
- **Stepper Motor** - A motor that derives its motion by receiving input signals (pulses) in a very specific sequence.

Common terminology

- **STL file** - Stereo lithography file format that has traditionally been associated with stereo lithography prototyping machines, but is now also being used to represent 3D surfaces for CNC tool path generating programs.
- **Tool Path** - A series of vector coordinate positions that define a cutting path. This cutting path can be a simple 2D or sophisticated 3D (even 4D or more) path used to machine out the shape of a desired part.
- **MDI** – Manual data entry, used for entering commands manually, line by line.
- **CAD** – Computer-aided design, the using of computers to assist and develop design.
- **CAM** – Computer-aided manufacturing, the use of computers to assist in manufacturing.
- **Feed Rate** – A multi character code containing the letter F followed by digits that determine the machines rate of movement.
- **H.M.I** - Human machine interface.

Laser Cutting

- **Laser cutting** is a technology that uses a laser to vaporize materials, resulting in a cut edge.
- While typically used for industrial manufacturing applications, even schools are using it.



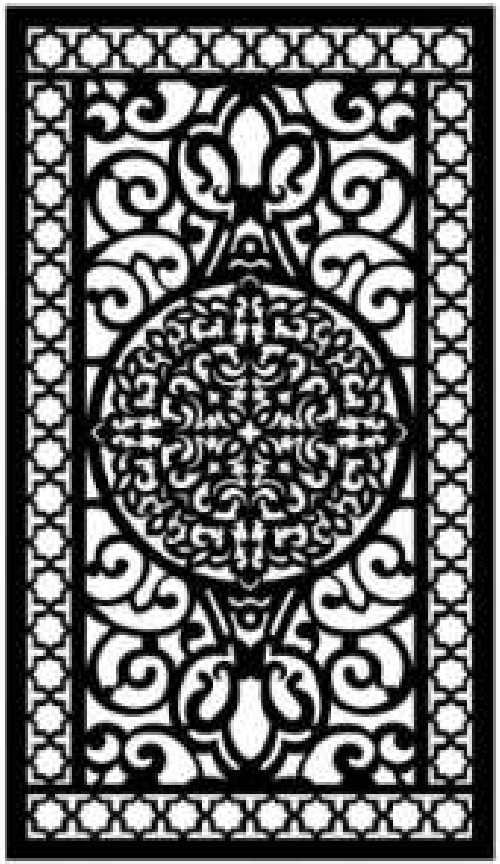
Principle of CO2 Laser

- LASER is the acronym for Light Amplification by Stimulated Emission of Radiation.
- A CO2 laser works by electrically stimulating the molecules within a carbon dioxide gas mixture.
- When focused through a lens, this highly-intense, invisible beam will vaporize many materials.
- Depending on the speed and intensity of the projected beam, a CO2 laser may be used to engrave or cut through a wide variety of materials.

Safety Precautions

- 1. Do not look at the laser while the piece is being cut. It could hurt
- your eyes.
- 2. Ensure that the shutter of the machine is closed while the work is
- going on.
- 3. Avoid inhaling the gases produced on cutting acrylic. Instead, let the shutter be closed for about 3-4 minutes after cutting so that all the obnoxious fumes exit through the exhaust.

Typical part made using Laser cutter



Rapid Prototyping

• They are technologies that have been adapted from the conventional manufacturing and assembly operations or developed from scratch to serve the special functions or needs of designers and manufacturers.

• Rapid prototyping is a collection of processes used to fabricate a
• model, part, or tool in minimum possible time.

Why is it needed

• Rapid prototyping (RP) is a family of fabrication methods to make engineering prototypes in minimum possible lead times based on a computer-aided design (CAD) model of the item.

• The traditional method of fabricating a prototype part is machining, which can require significant lead times—up to several weeks sometimes longer, depending on part complexity, difficulty in ordering materials, and scheduling production equipment

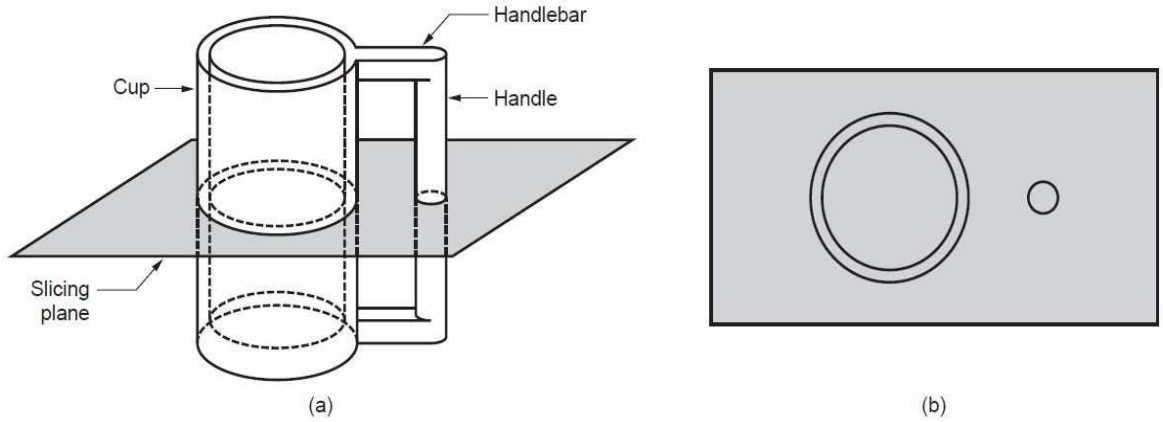
Importance

- The creation of a prototype is an integral step in the design
- procedure.
- A virtual prototype, which is a computer model of the part design on
- a CAD system, may not be adequate for the designer to visualize the
- part.
- It certainly is not sufficient to conduct real physical tests on the part, although it is possible to perform simulated tests by finite element analysis or other methods.

Geometric Modeling

This consists of modeling the component on a CAD system to define its enclosed volume. Solid modeling is the preferred technique because it provides a complete and unambiguous mathematical representation of the geometry.

For rapid prototyping, the important issue is to distinguish the interior (mass) of the part from its exterior, and solid modeling provides for this distinction

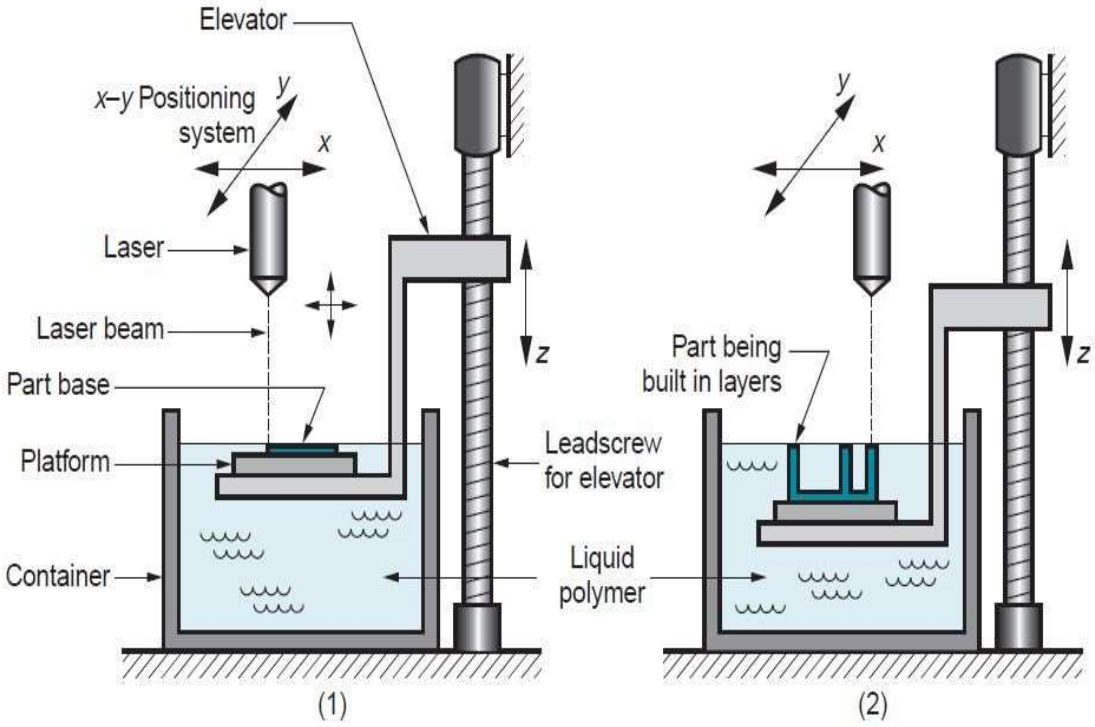


In this next step, the CAD model is converted into a format that approximates its surfaces by triangles or polygons, with their vertices arranged to distinguish the object's interior from its exterior. The common format used in rapid prototyping is STL, which has become the de facto standard input format for nearly all RP systems.

Liquid based technique- Stereolithography

Stereolithography (STL) is a process for fabricating a solid plastic part out of a photosensitive liquid polymer using a directed laser beam to solidify the polymer.

Part fabrication is accomplished as a series of layers, in which one layer is added onto the previous layer to gradually build the desired three dimensional geometry. A part fabricated by STL is illustrated in Figure. Each layer is 0.076 to 0.50mm thick. Thinner layers provide better resolution and allow more intricate part shapes



Materials for Stereolithography

- Photopolymers are typically acrylic , although use of epoxy for STL has also been reported .
- The starting materials are liquid monomers.
- Polymerization occurs upon exposure to ultraviolet light produced by helium-cadmium or argon ion lasers. Scan speeds of STL lasers typically range between 500 and 2500 mm/s.

Solid based rapid prototyping systems

- The main feature in these RP systems is that the starting material is solid.
- Most common process is called Fusion Deposition Modelling (FDM).

Fusion deposition modeling

- Fused-deposition modeling (FDM) is an RP process in which a filament of polymer is extruded onto the existing part surface from a work head to complete each new layer.
- The work head is controlled in the x-y plane during each layer and then moves up by a distance equal to one layer in the z-direction.
- The starting material is a solid filament with typical diameter of 1.25 mm fed from a spool into the work head that heats the material to about 0.5^0C above its melting point before extruding it onto the part surface.
- The extrudate is solidified and cold welded to the cooler part surface in about 0.1 second.
- The part is fabricated from the base up, using a layer-by-layer procedure similar to other RP systems.

FDM schematic