ME3493 MANUFACTURING TECHNOLOGY

CONTENTS

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OBJECTIVES:

1 To study the concepts and basic mechanics of metal cutting and the factors affecting machinability
2 To learn working of basic and advanced turning machines.
3 To teach the basics of machine tools with reciprocating and rotating motions and abrasive finishing processes.
4 To study the basic concepts of CNC of machine tools and constructional features of CNC.
5 To learn the basics of CNC programming concepts to develop the part programme for Machine centre and turning centre

UNIT - I THEORY OF METAL CUTTING 9

Mechanics of chip formation, forces in machining, Types of chip, cutting tools – single point cutting tool nomenclature, orthogonal and oblique metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability.

UNIT - II TURNING MACHINES 9

Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, surface roughness in turning, machining time and power estimation. Special lathes - Capstan and turret lathes- tool layout – automatic lathes: semi-automatic – single spindle: Swiss type, automatic screw type – multi spindle

UNIT - III RECIPROCATING MACHINE TOOLS 9

Reciprocating machine tools: shaper, planer, slotter: Types and operations- Hole making: Drilling, reaming, boring, tapping, type of milling operations-attachments- types of milling cutters– machining time calculation - Gear cutting, gear hobbing and gear shaping – gear finishing methods Abrasive processes: grinding wheel – specifications and selection, types of grinding process – cylindrical grinding, surface grinding, centerless grinding, internal grinding - micro finishing methods

UNIT - IV CNC MACHINES 9

Computer Numerical Control (CNC) machine tools, constructional details, special features – Drives, Recirculating ball screws, tool changers; CNC Control systems – Open/closed, point-to-point/continuous - Turning and machining centres – Work holding methods in Turning and machining centres, Coolant systems, Safety features.

UNIT - V PROGRAMMING OF CNC MACHINE TOOLS 9

Coordinates, axis and motion, Absolute vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers – Fixed cycles, Loops and subroutines, Setting up a CNC machine for machining.

TOTAL : 45 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Apply the mechanism of metal removal process and to identify the factors involved in improving machinability.
2. Describe the constructional and operational features of centre lathe and other special purpose lathes.
3. Describe the constructional and operational features of reciprocating machine tools.
4. Apply the constructional features and working principles of CNC machine tools.
5. Demonstrate the Program CNC machine tools through planning, writing codes and setting up CNC machine tools to manufacture a given component.

TEXT BOOKS:

1. Kalpakjian. S, “Manufacturing Engineering and Technology”, Pearson Education India,7th Edition, 2018.
2. Michael Fitzpatrick, Machining and CNC Technology, McGraw-Hill Education; 4th edition, 2018.

REFERENCES:

1. Roy. A. Lindberg, Processes and materials of manufacture, PHI / Pearson education, 2006.
2. Geofrey Boothroyd, “Fundamentals of Metal Machining and Machine Tools”, McGraw Hill, 1984.
3. Rao. P.N “Manufacturing Technology,” Metal Cutting and Machine Tools, Tata McGraw- Hill, New Delhi, 2009.
4. A. B. Chattopadhyay, Machining and Machine Tools, Wiley, 2nd edition, 2017.
5. Peter Smid, CNC Programming Handbook, Industrial Press Inc.,; Third edition, 2007

UNIT I

THEORY OF METAL CUTTING

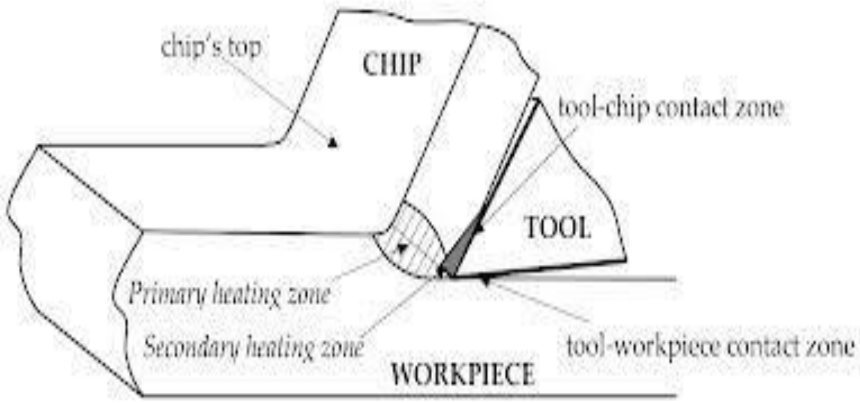
Definitions

Machining: Term applied to all material-removal processes

Metal cutting: The process in which a thin layer of excess metal (chip) is removed by a wedge-shaped single-point or multipoint cutting tool with defined geometry from a work piece, through a process of extensive plastic deformation

1.1 MECHANICS OF CHIP FORMATION

The cutting itself is a process of extensive plastic deformation to form a chip that is removed afterward. The basic mechanism of chip formation is essentially the same for all machining operations. Assuming that the cutting action is continuous, we can develop so-called continuous model of cutting process.



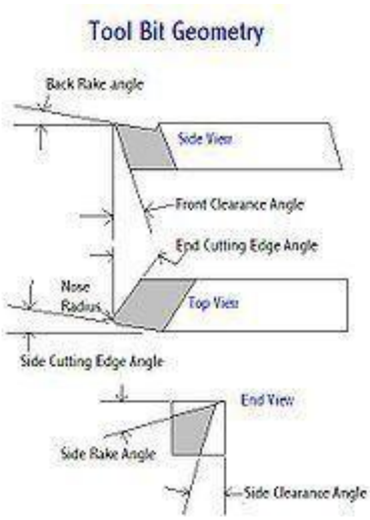
The cutting model shown above is oversimplified. In reality, chip formation occurs not in a plane but in so-called primary and secondary shear zones, the first one between the cut and chip, and the second one along the cutting tool face.

1.2 Single-point cutting tool,

As distinguished from other cutting tools such as a The cutting edge is ground to suit a particular machining operation and may be re sharpened or reshaped as needed. The ground tool bit is held rigidly by a tool holder while it is cutting.

Back Rake is to help control the direction of the chip, which naturally curves into the work due to the difference in length from the outer and inner parts of the cut. It also helps counteract the pressure against the tool from the work by pulling the tool into the work.

Side Rake along with back rake controls the chip flow and partly counteracts the resistance of the work to the movement of the cutter and can be optimized to suit the particular material being cut. Brass for example requires a back and side rake of 0 degrees while aluminum uses a back rake of 35 degrees and a side rake of 15 degrees. Nose Radius makes the finish of the cut smoother as it can overlap the previous cut and eliminate the peaks and valleys that a pointed tool produces. Having a radius also strengthens the tip, a sharp point being quite fragile.



All the other angles are for clearance in order that no part of the tool besides the actual cutting edge can touch the work. The front clearance angle is usually 8 degrees while the side clearance angle is 10-15 degrees and partly depends on the rate of feed expected.

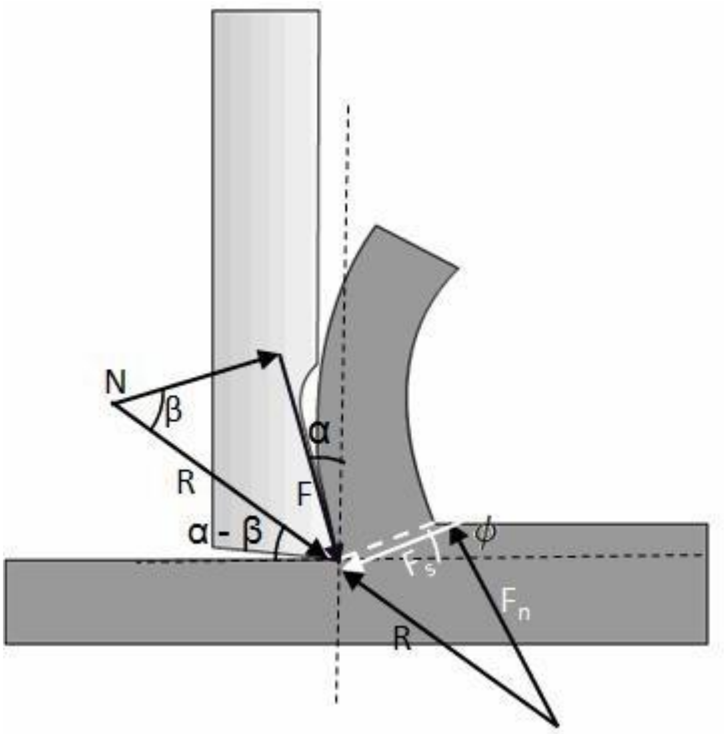
Minimum angles which do the job required are advisable because the tool gets weaker as the edge gets keener due to the lessening support behind the edge and the reduced ability to absorb heat generated by cutting.

The Rake angles on the top of the tool need not be precise in order to cut but to cut efficiently there will be an optimum angle for back and side rake.

1.3 Forces in machining

If you make a free body analysis of the chip, forces acting on the chip would be as follows.

At cutting tool side due to motion of chip against tool there will be a frictional force and a normal force to support that. At material side thickness of the metal increases while it flows from uncut to cut portion. This thickness increase is due to inter planar slip between different metal layers. There should be a shear force (Fs) to support this phenomenon. According to *shear plane theory* this metal layer slip happens at single plane called shear plane. So shear force acts on shear plane. Angle of shear plane can approximately determined using *shear plane theory* analysis. It is as follows $\phi = 45^o + \frac{\alpha}{2} - \frac{\beta}{2}$



Forces acting on the chip on tool side and shear plane side

Shear force on shear plane can be determined using shear strain rate and properties of material. A normal force (Fn) is also present perpendicular to shear plane. The resultant force (R) at cutting tool side and metal side should balance each other in order to make the chip in equilibrium. Direction of resultant force, R is determined as shown in Figure.

1.4 Types of chip

There are three types of chips that are commonly produced in cutting,

Discontinuous chips

Continuous chips

Continuous chips with built up edge

A discontinuous chip comes off as small chunks or particles. When we get this chip it may indicate,

Brittle work material

Small or negative rake angles

Coarse feeds and low speeds

A continuous chip looks like a long ribbon with a smooth shining surface. This chip type may indicate,

Ductile work materials

Large positive rake angles

Fine feeds and high speeds

Continuous chips with a built up edge still look like a long ribbon, but the surface is no longer smooth and shining. Under some circumstances (low cutting speeds of ~0.5 m/s, small or negative rake angles),

Work materials like mild steel, aluminum, cast iron, etc., tend to develop so-called built-up edge, a very hardened layer of work material attached to the tool face, which tends to act as a cutting edge itself replacing the real cutting tool edge. The built-up edge tends to grow until it reaches a critical size (~0.3 mm) and then passes off with the chip, leaving small fragments on the machining surface. Chip will break free and cutting forces are smaller, but the effects is a rough machined surface. The built-up edge disappears at high cutting speeds.

Chip control

Discontinuous chips are generally desired because

They are less dangerous for the operator

Do not cause damage to workpiece surface and machine tool

Can be easily removed from the work zone

Can be easily handled and disposed after machining.

There are three principle methods to produce the favorable discontinuous chip:

Proper selection of cutting conditions

Use of chip breakers

Change in the work material properties

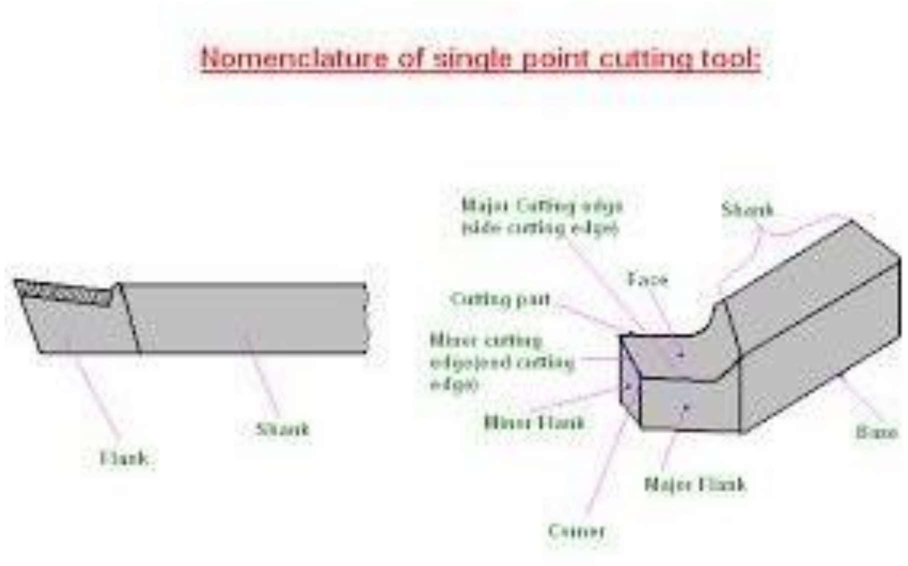
Chip breaker

Chip break and chip curl may be promoted by use of a so-called chip breaker. There are two types of chip breakers

External type, an inclined obstruction clamped to the tool face

Integral type, a groove ground into the tool face or bulges formed onto the tool face

1.5 Cutting tool nomenclature



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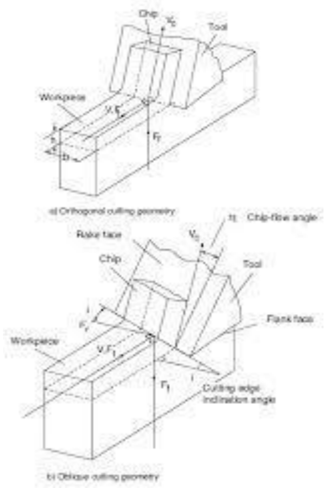
1.6 Orthogonal metal cutting



Orthogonal metal cutting	Oblique metal cutting
Cutting edge of the tool is perpendicular to the direction of tool travel.	The cutting edge is inclined at an angle less than 90^o to the direction of tool travel.
The direction of chip flow is perpendicular to the cutting edge.	The chip flows on the tool face making an angle.
The chip coils in a tight flat spiral	The chip flows side ways in a long curl.
For same feed and depth of cut the force which shears the metal acts on smaller areas. So the life of the tool is less.	The cutting force acts on larger area and so tool life is more.
Produces sharp corners.	Produces a chamfer at the end of the cut
Smaller length of cutting edge is in contact with the work.	For the same depth of cut greater length of cutting edge is in contact with the work.
Generally parting off in lathe, broaching and slotting operations are done in this method.	This method of cutting is used in almost all machining operations.

Depending on whether the stress and deformation in cutting occur in a plane (two-dimensional case) or in the space (three-dimensional case), we consider two principle types of cutting:

Orthogonal cutting the cutting edge is straight and is set in a position that is perpendicular to the direction of primary motion. This allows us to deal with stresses and strains that act in a plane.

Oblique cutting the cutting edge is set at an angle.

According to the number of active cutting edges engaged in cutting, we distinguish again two types of cutting:

Single-point cutting the cutting tool has only one major cutting edge

Examples: turning, shaping, boring

Multipoint cutting the cutting tool has more than one major cutting edge

Examples: drilling, milling, broaching, reaming. Abrasive machining is by definition a process of multipoint cutting.

Cutting conditions

Each machining operation is characterized by cutting conditions, which comprises a set of three elements:

Cutting velocity: The traveling velocity of the tool relative to the work piece. It is measured in m/s or m/min.

Depth of cut: The axial projection of the length of the active cutting tool edge, measured in mm. In orthogonal cutting it is equal to the actual width of cut.

Feed: The relative movement of the tool in order to process the entire surface of the work piece. In orthogonal cutting it is equal to the thickness of cut and is measured in mm.

1.7 Thermal aspects

In cutting, nearly all of energy dissipated in plastic deformation is converted into heat that in turn raises the temperature in the cutting zone. Since the heat generation is closely related to the plastic deformation and friction, we can specify three main sources of heat when cutting,

Plastic deformation by shearing in the primary shear zone

Plastic deformation by shearing and friction on the cutting face

Friction between chip and tool on the tool flank

Heat is mostly dissipated by,

The discarded chip carries away about 60~80% of the total heat

The workpiece acts as a heat sink drawing away 10~20% heat