Unit-1: Metal Cutting

(Subject: Manufacturing Technology)

MANUFACTURING: It is an industrial activity, in which raw material is changed in to products. It can be classified in to;

1. Forming: Forging, Rolling, Extrusion, Blanking, piercing, bending, embossing, coining etc.
2. Casting
3. Welding
4. Machining: Traditional (i.e. chip removal) and non-traditional (erosion, abrasion)

CLASSIFICATION OF MANUFACTURING PROCESSES

The manufacturing process used in engineering industries basically perform one or more of the following functions:

1. Change the physical properties of the work material.
2. Change the shape and size of the work piece.
3. Produce desired dimensional accuracy and surface finish.

Based on the nature of work involved these processes may be divided into following seven categories:

1. Processes for changing physical properties of the materials – Hardening, Tempering, Annealing, Surface Hardening.
2. Casting Processes – Sand Casting, Permanent mold casting, die casting, Centrifugal casting
3. Primary metal working processes – Rolling, forging, extrusion, wire drawing
4. Shearing and Forming processes – Punching, blanking, drawing, bending, forming
5. Joining processes – Welding, brazing, soldering, joining
6. Machining Processes – Turning, drilling, milling, grinding
7. Surface finishing processes – Lapping, honing, superfinishing

PRODUCTION: The process of transforming resources into finished products is known as Production. Production involves the creation of the utility.

Classification of Production Systems

Production systems can be classified as Job-shop, Batch, Mass and Continuous production systems as shown in Fig 1.

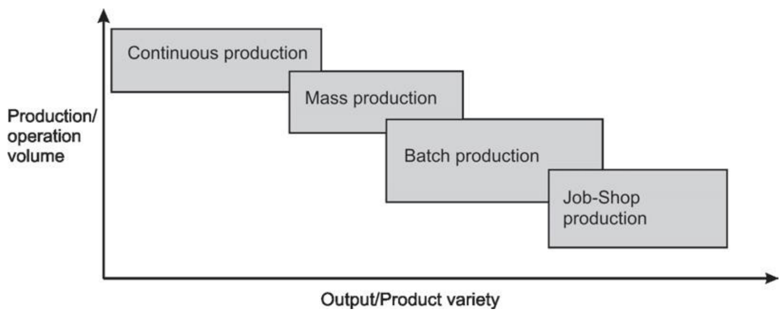


Fig. 1 Classifications of production systems

1. Job-Shop Production

In Job-shop production, manufacturing one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products. A job-shop comprises of general-purpose machines and it is characterized by:

a) High variety of products and low volume.

b) Use of general purpose machines and facilities.

c) Highly skilled operators who can take up each job as a challenge because of uniqueness.

d) Large inventory of materials, tools, parts.

e) Detailed planning is essential for sequencing the requirements of each product, capacities for each work centre and order priorities.

Advantages

a) Because of general purpose machines and facilities variety of products can be produced.

b) Operators will become more skilled and competent, as each job gives them learning opportunities.

c) Full potential of operators can be utilized.

Limitations

Following are the limitations of Job-shop Production:

a) Higher cost due to frequent set up changes.

b) Higher level of inventory at all levels and hence higher inventory cost.

c) Production planning is complicated.

d) Larger space requirements.

2. Batch Production

In batch Production, the job pass through the functional departments in lots or batches and each lot may have a different routing. It include the manufacture of limited number of products produced at regular intervals.

Advantages

a) Better utilization of plant and machinery.
b) Promotes functional specialization.
c) Cost per unit is lower as compared to job order production.
d) Lower investment in plant and machinery.
e) Flexibility to accommodate and process number of products.
f) Job satisfaction exists for operators.

Limitations

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.
3. Work in process inventory is higher compared to continuous production.
4. Higher set up costs due to frequent changes in set up.

3. Mass Production

It has very large volume of production. The machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path.
Mass Production is characterized by

a) Standardization of product and process sequence.
b) Dedicated special purpose machines having higher production capacities and output rates.
c) Large volume of products.
d) Shorter cycle time of production.
e) Material handling can be completely automatic.

Advantages

a) Higher rate of production with reduced cycle time.
b) Less skilled operators are required.
c) Low process inventory.
d) Manufacturing cost per unit is low.

Limitations

a) Breakdown of one machine will stop an entire production line.
b) Line layout needs major change with the changes in the product design.
c) High investment in production facilities.
d) The cycle time is determined by the slowest operation.

4. Continuous Production

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

Continuous Production is characterized by

a) Dedicated plant and equipment with zero flexibility.
b) Material handling is fully automated.
c) Process follows a predetermined sequence of operations.

Advantages

a) Standardization of product and process sequence.
b) Higher rate of production with reduced cycle time.
c) Higher capacity utilization due to line balancing.
d) Manpower is not required for material handling as it is completely automatic.
e) Person with limited skills can be used on the production line.
f) Unit cost is lower due to high volume of production.

Limitations

a) Flexibility to accommodate and process number of products does not exist.
b) Very high investment for setting flow lines.
c) Product differentiation is limited.

The difference between Manufacturing and Production

1. In manufacturing, the use of machinery is a must whereas production can be done with or without the use of machinery.
2. All types of manufacturing activities are used in production, but production may not necessarily be known as manufacturing.
3. In manufacturing, the output generated will be tangible in nature, i.e. goods only, but in the case of manufacturing it produces both tangible and intangible outputs, i.e. goods as well as services.
4. Men-machine setup should be there for manufacturing of goods, which is not in the case of production, the only man is sufficient for producing output.
5. Manufacturing can be distinguished as a part of production process. Manufacturing usually finds its use in industrial sector. In manufacturing, there is proper plan to make a final good or product. The goods which are manufactured are the ones which the consumer can directly consume or use. In Manufacturing, company procures raw materials or components from

outside. For example take the making of a car. Different systems like transmission system or tyres are done at different locations and procured at a plant and fixed to make a car.

6. Production is broader among the two. Production also requires the involvement of employees. This involves converting input to output. The inputs in this may not necessarily be raw material to make a product but input may be in the form of investment as well. For example take a movie production. The producers of a movie give inputs such as providing all the facilities and equipment to make a movie.

7. Tangible goods can be manufactured but intangible goods can only be produced.

MACHINE TOOL

Machine tool is any stationary power-driven machine that is used to shape or form parts made of metal or other materials. The shaping is performed in four general ways:

a) By cutting excess material in the form of chips from the part

b) By shearing the material

c) By squeezing metallic parts to the desired shape; and

d) By applying electricity, ultrasound, or corrosive chemicals to the material.

The fourth category covers modern machine tools and processes for machining ultrahard metals not machinable by older methods. Common types of machine tools used in industry are, lathe, grinder, milling, planner, broaching, shaper etc.

Functions of machine tool

Every machine tool should perform the following functions;

1. To hold and support the job or workpice to be machined.
2. To hold and support the cutting tool in position.
3. To move the cutting tool, workpiece or both of them n a desired position.
4. To regulate the cutting speed and provide the feeding movement to one of these.

Classification of machine tools

Machine tools can be classified in to following;

1. Standard machine tools
2. Special purpose machine tools

Standard machine tools are capable of performing a number of different perations, and thus produce a large variety of jobs having different shapes and sizes. Whereas, special purpose machine tools are designed to perform only some specified operations so as to produce some specified operations so as to produce identical items.

Selection of machine tools

1. The machine tools should be selected that can reduce labour cost and other general charges to minimum
2. Atleast, one motor should be present to drive the workpiece and the machine tool itself.
3. The slides should be machined precisely. They must have high wear resistance and be hardened.

Machining

It is used to described removal of material from a workpiece with the help of cutting tool to give desired shape and size, it covers several processes, which we usually divide in to following categories as;

a) Cutting, generally involving single-oint or multipoint cutting tools, each with a clearly defined geometry.

b) Abrasive processes, such as grinding.

c) Non-traditional machining processes using electrical, chemical etc. energy.

ORTHOGONAL AND OBLIQUE CUTTING

In orthogonal cutting, cutting force is always perpendicular to the cutting edge of tool. But in oblique cutting, cutting force is inclined to the cutting edge of the tool with an acute angle.(i.e angle less than 90) as shown in Fig. 2. Orthogonal cutting is known as two dimensional cutting and oblique cutting is known as three dimensional cutting. In orthogonal cutting chip moves normally outwards from chip tool interface whereas in oblique cutting chip moves always away from the chip tool interface at inclination angle.

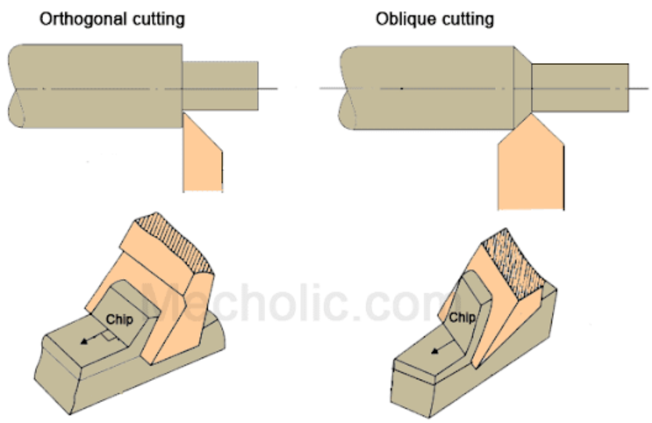


Fig. 2 (a) Orthogonal cutting (b) Oblique cutting

TYPES OF CHIPS IN METAL CUTTING

Different types of chips are produced in metal cutting during machining process as shown in Fig. 3. The machining of material is highly dependable on chips. Machining is a process of cutting metal work piece by means of a tool to convert it into desire shape. It is a finishing or semi finishing process by removal of excess material from work piece. The excess material removes from work piece in form of chips.

The type of chips depends on;

* Nature of work piece
* Nature of tool
* Dimension of tool
* Feed rate
* Cutting speed
* Friction between tool and work piece
* Cutting environment like temperature, friction etc.

Chips formation is a part of machining process. The chips depend on the material of work piece and tool and cutting condition. There are mainly three chips types

1. Continuous chips

According to its name, continuous chips have a continuous segment. This chip is formed during cutting of ductile material like aluminum, mild steal, cooper etc. with a high cutting speed. The friction between tool and material is minimum during this process. This is formed due to continuous plastic deformation of the material by application of tool. These chips have equal thickness throughout the length. It generally gives good surface finish.

The most favorable conditions of forming continuous chips are

a) Work piece should have ductile in nature.
b) The rack angle should be large.
c) Friction between work piece and tool should minimum.
d) Cutting speed should high.
e) Depth of cut should be small.
f) Proper use of coolant and lubricant.
g) Tool should have low coefficient of friction.

Continuous chips are the most preferable type of chip due to following benefits.

a) It gives high surface finish of machining ductile material.
b) Continuous chips form when low friction which minimize friction loss.
c) Due to low friction, tool life is high.
d) Power consumption is low.

2. Discontinuous chips or segmental chip

According to its name, this chips form in segment. It is form when machining of brittle material like cast iron, brass etc. with slow cutting speed. Chips cut into small segment during cutting. This is formed during slow cutting speed with small rack angle. This chips form in ductile material when the friction between tool and work piece is high. Discontinuous chips in ductile material give poor surface finish and slow machine. It is suitable form of chips of machining brittle material.

The favorable conditions of forming this type of chip are

a. The work piece should have brittle in nature.
b. Slow speed of cutting
c. Small rack angle of tool
d. Depth of cut should large

3. Continuous Chips with built up edge (BUE)

This type of chip is same as the continuous chips except a built edge is form at the face of tool. It is form during machining of ductile metal with excessive friction between tool and work piece. This chip is not smooth as continuous chips. The built up edge form due to high temperature between tool and work piece. This high temperature is due to high friction force between tool and work piece.

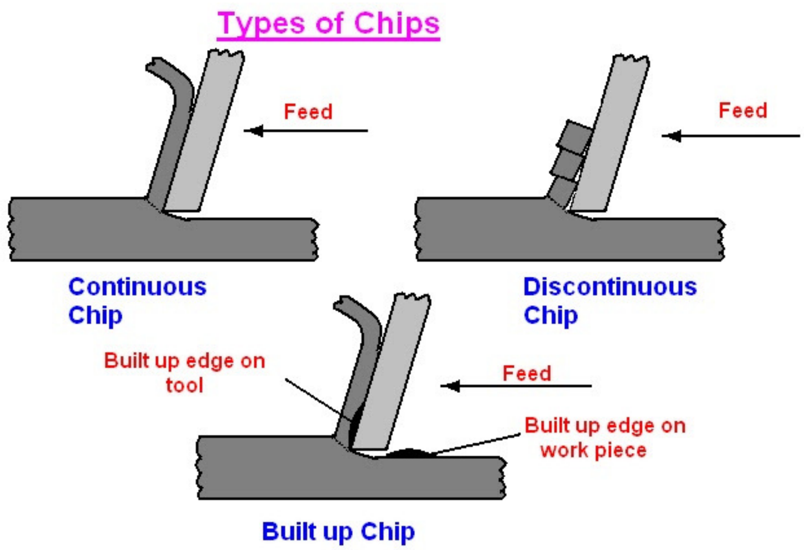


Fig. 3 Types of Chips

a. Cutting of ductile metal.
b. High friction force at the face of tool.
c. High temperature between tool and work piece.
d. Lack of coolant and lubricant

Comparison of Continuous chips, Discontinuous chips and Continuous chips with built edge:

S. No.	Material type	Rack angle	Depth of cut	Cutting speed
Continuous Chips	Ductile	High	Small	Large/medium
Discontinuous Chips	Brittle, Ductile but hard	Medium	High	Low
Continuous chips with built edge	Ductile	Low/Medium	Medium	Medium

GEOMETRY OF SINGLE POINT CUTTING TOOL

As its name indicates, a tool that has a single point for cutting purpose is called single point cutting tool as shown in Fig.4 (a) and Fig. 4 (b) . It is generally used in the lathe machine, shaper machine etc to remove the materials from the workpiece.

The shape and angle of tool face and cutting edge is known as tool geometry. Tool geometry depends on the following;

1. Tool and work material
2. Cutting conditions

3. Types of cutting

Terms and definitions

Shank: It is that part of single point cutting tool which goes into the tool holder. Or in simple language shank is used to hold the tool.

Flank: It is the surface below and adjacent of the cutting edges. There are two flank surfaces, first one is major flank and second one is minor flank. The major flank lies below and adjacent to the side cutting edge and the minor flank surface lies below and adjacent to the end cutting edge.

Base: The portion of the shank that lies opposite to the top face of the shank is called base.

Face: It is the top portion of the tool along which chips slides. It is designed in such a way that the chips slides on it in upward direction.

Cutting edge: The edge on the tool which removes materials from the work piece is called cutting edges. It lies on the face of the tool. The single point cutting tool has two edges and these are

(**i) Side cutting edge:** The top edge of the major flank is called side cutting edge.

(ii) End cutting edge: The top edge of the minor flank is called end cutting edge.

Nose or cutting point: The intersection point of major cutting edge and minor cutting edge is called nose.

Nose radius: It is the radius of the nose. Nose radius increases the life of the tool and provides better surface finish.

Heel: It is a curved portion and intersection of the base and flank of the tool.

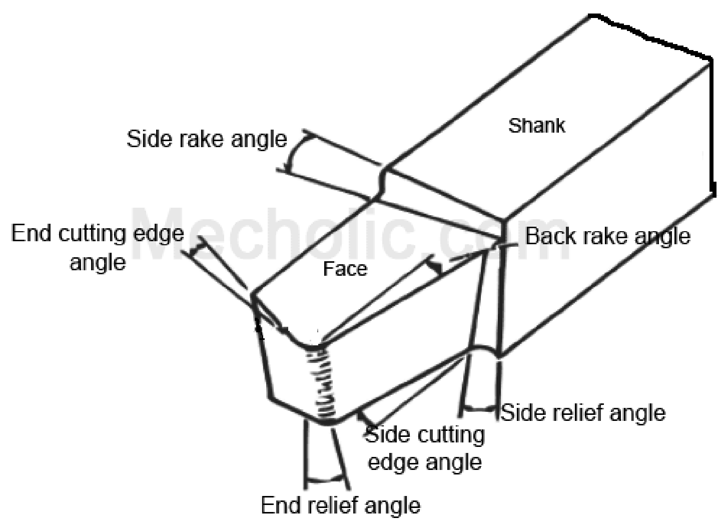


Fig. 4(a)

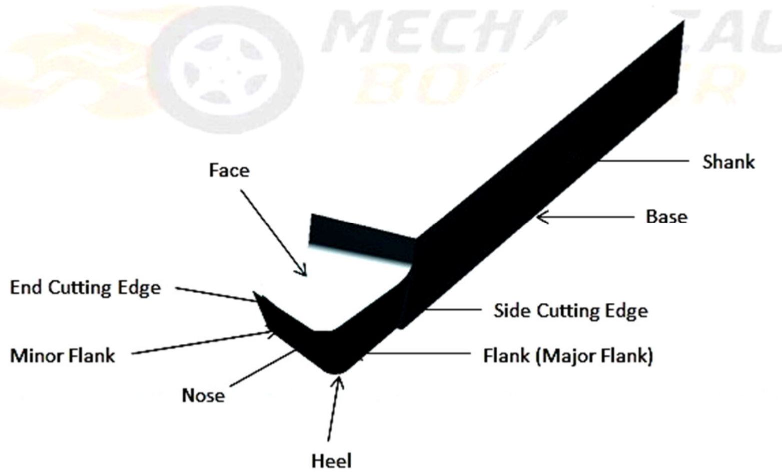


Fig. 4 (b)

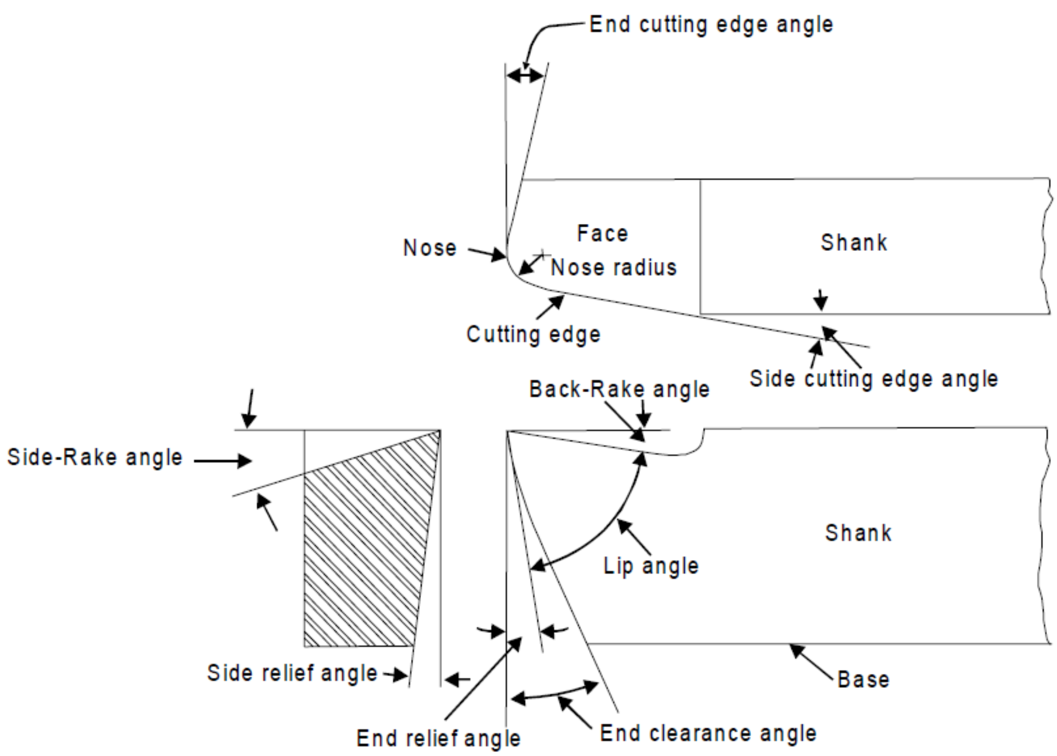


Fig. 4 (c)

(a) Back rake angle

As shown in Fig. 4 (c), Back rake angle is the angle between the face of the single point cutting tool and a line parallel with base of the tool measured in a perpendicular plane through the side cutting edge. If the slope face is downward toward the nose, it is negative back rake angle and if it is upward toward nose, it is positive back rake angle. Back rake angle helps in removing the chips away from the work piece.

(b) Side rake angle

Side rake angle is the angle by which the face of tool is inclined sideways. Side rake angle is the angle between the surface the flank immediately below the point and the line down from the point perpendicular to the base. Side rake angle of cutting tool determines the thickness of the tool behind the cutting edge. It is provided on tool to provide clearance between work piece and tool so as to prevent the rubbing of work piece with end flake of tool.

(c) End relief angle

End relief angle is defined as the angle between the portion of the end flank immediately below the cutting edge and a line perpendicular to the base of the tool, measured at right angles to the flank. End relief angle allows the tool to cut without rubbing on the work piece.

(d) Side relief angle

Side rake angle is the angle between the portion of the side flank immediately below the side edge and a line perpendicular to the base of the tool measured at right angles to the side. Side relief angle is the angle that prevents the interference as the tool enters the material. It is incorporated on the tool to provide relief between its flank and the work piece surface.

(e) End cutting edge angle

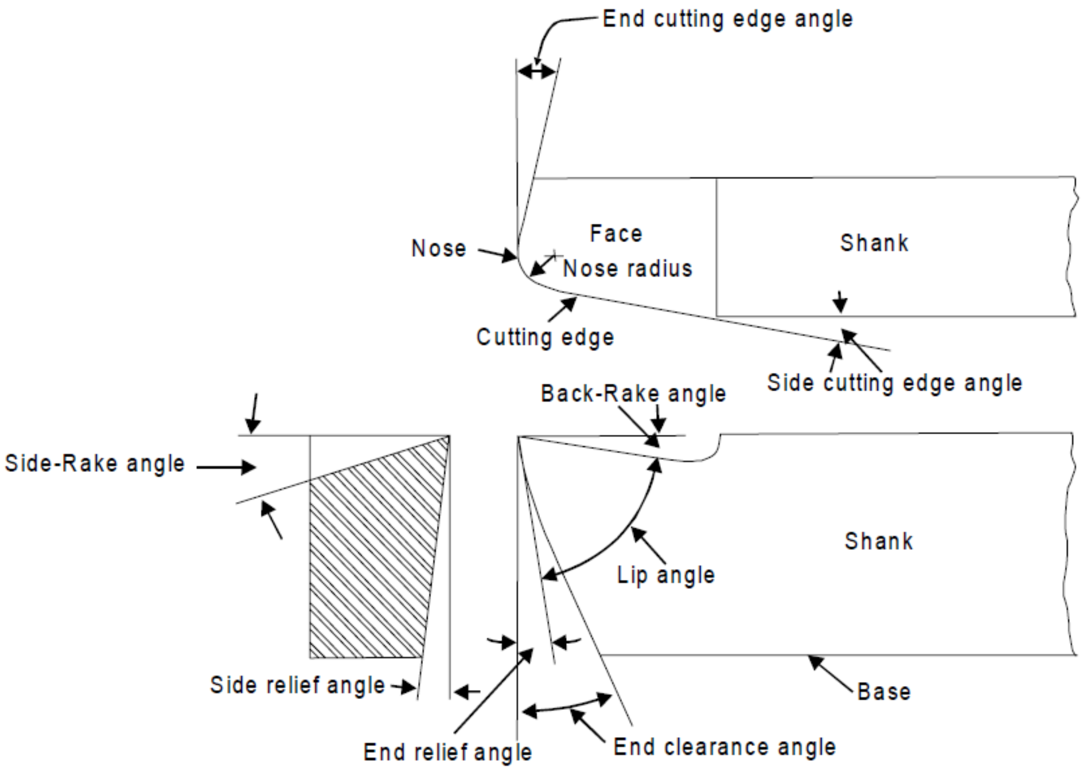
End cutting edge angle is the angle between the end cutting edge and a line perpendicular to the shank of the tool. It provides clearance between tool cutting edge and work piece.

(f) Side cutting edge angle

Side cutting edge angle is the angle between straight cutting edge on the side of tool and the side of the shank. It is responsible for turning the chip away from the finished surface.

TOOL SIGNATURE OF SINGLE POINT CUTTING TOOL

Tool signature or tool designation is a convenient way to describe the tool anlges by using the standard abbreviated system. The main types of tool signature system are;



Elements of tool signature

1. American Standard Association (ASA)

2. Orthogonal Rake System (ORS) or International system

Generally, American Standard Association system is used. The ASA system consists of seven elements to denote a single point cutting tool. They are always written in the following order as;

1. Back rake angle (0°)
2. Side rake angle (7°)
3. End relief angle (6°)
4. Side relief angle (8°)
5. End cutting edge angle (15°)
6. Side cutting edge angle (16°) and
7. Nose radius (0.8 mm)

It is usual to omit the symbols for degrees and mm, simply listing the numerical value of each component in single point cutting tool:

A typical tool signature is 0-7-6-8-15-16-0.8

CUTTING PARAMETERS

In metal cutting, various cutting parameters like cutting speed, feed rate, depth of cut, tool material, work material etc are involved (Fig. 5).

Cutting speed is defined as the speed at which the work moves with respect to the tool. Cutting speed is always expressed in meters per minute (m/min) or in feet per minute (ft/min.

Feed rate is defined as the distance the tool travels during one revolution of the part. Cutting speed and feed determines the surface finish, power requirements, and material removal rate.

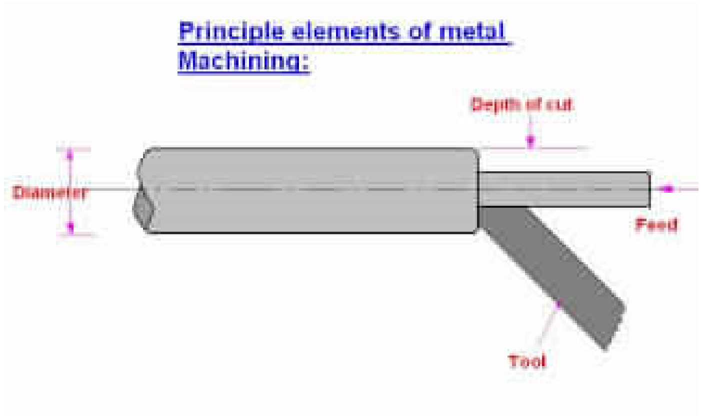


Fig. 5: Cutting Speed, Feed and Depth Of Cut

Depth of Cut is the distance that the tool bit moves into the work. usually measured in in millimeters. General machine practice is to use a depth of cut up to five times the rate of feed,

CUTTING FLUIDS

Cutting fluid is a type of coolant and lubricant designed specifically for metalworking processes, such as machining and stamping. There are various kinds of cutting fluids, which include oils, oil-water emulsions, pastes, gels, aerosols (mists), and air or other gases. They may be made from petroleum distillates, animal fats, plant oils, water and air, or other raw ingredients. Cutting fluids are used to improving tool life, reducing workpiece thermal deformation, improving surface finish and flushing away chips from the cutting zone. Cutting fluids can be divided in to four categories:

1. Straight oils
2. Soluble oils
3. Synthetic fluids
4. Semi-synthetic fluids

1. **Straight oils**: Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contains polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorus. Straight oils provide the best lubrication and the poorest cooling characteristics among cutting fluids.

2. **Soluble oils**: Soluble Oil fluids form an emulsion when mixed with water. The concentrate consists of a base mineral oil and emulsifiers helps to produce a stable emulsion. They are used in a diluted form (usual concentration = 3 to 10%) and provide good lubrication and heat transfer performance. They are widely used in industry and are the least expensive among all cutting fluids.
3. **Synthetics fluids**: Synthetic Fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. Synthetic fluids often provide the best cooling performance among all cutting fluids.
4. **Semi-synthetic fluids:** These are essentially combination of synthetic and soluble oil fluids and have characteristics common to both types. The cost and heat transfer performance of semi-synthetic fluids lie between those of synthetic and soluble oil fluids.

FUNCTIONS OF CUTTING FLUIDS

1. Cutting fluid cools the work piece and tool by carrying away the heat generated during machining.
2. It acts as lubricant at the friction zones, hence tool life increases.
3. As friction get reduced, the forces and electricity power consumption decreases.
4. Using cutting fluids produces better surface finish to the work piece.
5. It causes to break the chips into small pieces.
6. It washes away the chips from the tool.
7. It prevents the corrosion of chips and machine.
8. Improves dimensional accuracy and control on the work piece.
9. It permits maximum cutting speed hence the time for machining reduce and cost of manufacturing increases.

PROPERTIES OF AN IDEAL CUTTING FLUIDS

Cutting fluids should have low viscosity to permit free flow of the liquid.

1. It should posses good lubricating properties.
2. It should have high specific heat, high heat conductivity and high heat transfer coefficient.
3. It should be non-corrosive to work and machine.
4. It should be non-toxic to operating person.
5. It should be odourless.
6. It should stable in use and storage.
7. It should be safe.

8. It should permit clear view of the work operation.

Most commonly used cutting fluids are

Cast Iron: No cutting fluids are used.

Steels: Lord oil with mineral oil is used.

Alloy steel: Sulphur brass oil with mineral oil is used.

Copper: Soluble oil with 90 to 95% of water is used.

Aluminium: Mineral oil with soluble oil cutting fluids are used as cutting fluids.

SELECTION OF CUTTING FLUIDS

To select a cutting fluid for metal working operations, the advantages and disadvantages of metalworking cutting fluids should be compared through review of product literature, supplier information, and usage history.

The following factors should be considered when selecting a cutting fluid

- Cost and life expectancy
- Fluid compatibility with work materials and machine components
- Speed, feed and depth of the cutting operation
- Type, hardness and microstructure of the metal being machined
- Ease of fluid maintenance and quality control
- Ability to separate fluid from the work and cuttings
- Optimal concentration and pH ranges
- Storage practices

1.1 Chip breaker

A chip breaker is the tool which has a groove or an obstacle placed on the incline face of the tool. A chip breaker can be used for increasing chip breakability which results in efficient chip control and improved productivity. It also decreases cutting resistance, and gives a better surface finish to the workpiece. This also leads to a greater tool life. A chip breaker is usually used for improving chip breakability by decreasing the chip radius. The chip breaker pattern affects chip breakability.

The principle of chip breaker is that fracture is generated by the force and moment acting on chip surface.

The process of metal cutting by a single point cutting tool generates narrow and long chips that lead to problems such as difficulty in chip handling, surface damage of products, tangling together and safety hazards for the operator. Therefore, it is necessary to cut chips to the appropriate size.

Chips generated during metal cutting usually curl, and may strike against workpiece or tool, leading to chip breaking. Patterns and sizes of broken chips are different depending on deformation mechanism and collision location. The generated chip makes continuous curling and it is known that chip breakability enlarges when we reduce the up curling radius and down curling radius of a chip clearance that is formed at this time.

In determination of chip pattern, it is to be ensured that appropriate external force is applied to the chip, as it increases the fracture strain of the chip and decreases the radius of the chip.

Parameters like depth, land, breadth, radius of the chip breaker play a significant role in determining the chip breakability. These factors lead to better designs of chip breaker.

Indeed, much research has been accomplished, but it is difficult to break chips in the finishing of mild steel. The type of chip breakers available fall into categories of grooved and attached. From, the view point of tool strength, an attached chip breaker is better than grooved one.

1.2 Classification of chip pattern

Chip pattern has been classified by CIRP and INFOS, but each classification is very similar. Chip pattern classified by INFOS is illustrated in fig. 1

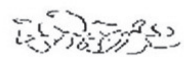
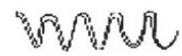
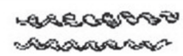
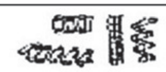
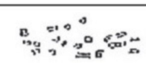
1		ribbon chips
2		tangled chips
3		corkscrew chips
4		helical chips
5		long tubular chips
6		short tubular chips
7		spiral tubular chips
8		spiral chips
9		long comma chips
10		short comma chips

Fig.1 Classification of chip pattern (INFOS)

2.1 Need and purpose of chip-breaking

Continuous machining like turning of ductile metals, produce continuous chips, which leads to their handling and disposal problems. The problems become acute when ductile but strong metals like steels are machined at high cutting velocity for high MRR by flat rake face type carbide or ceramic inserts. The sharp edged hot continuous chip that comes out at very high speed

- becomes dangerous to the operator and the other people working in the vicinity
- creates difficulties in chip disposal
- may impair the finished surface by entangling with the rotating job

Therefore it is essentially needed to break such continuous chips into small regular pieces for

- safety of the working people
- prevention of damage of the product
- Easy collection and disposal of chips.

Chip breaking is done in proper way also for the additional purpose of improving machinability by reducing the chip-tool contact area, cutting forces and crater wear of the cutting tool.

Therefore the purpose of this study is to solve the problems of continuous chip and construct the basis of improved factory automation by using chip breakers of the attached obstruction type, which represents a new concept in chip breaking.

In this project, parameters like cutting speed, feed, depth of cut, height and width of chip breaker will be studied and how they effect the chip breakability, so that better control of chip can be done.

thickness. The minimum position of the chip-breaker is around 17 times the uncut chip-thickness for all possible modes of deformation.

M. Rahman et.al [6], has dealt with a three-dimensional model of chip flow, chip curl and chip breaking, taking into account the geometrical, the kinetic, as well as the mechanical features. For all these, a set of equivalent characteristic parameters was defined and a relationship was developed between these and the actual machining parameters.

G. Sutter et.al [7], presented a 'dimensional analysis' of the root chip in orthogonal cutting. Different models of the chip length contact were validated at the sight of experimental measurements. The chip thickness ratio tends to 1 when the uncut chip thickness increases. The principle of minimum rate of work was confirmed with the effect of the cutting speed on the shear angle.

3.2 Principles of chip-breaking

The principles and methods of chip breaking are generally classified as follows:

- **Self breaking**: This is accomplished without using a separate chip-breaker either as an attachment or an additional geometrical modification of the tool.
- **Forced chip breaking** by additional tool geometrical features or devices

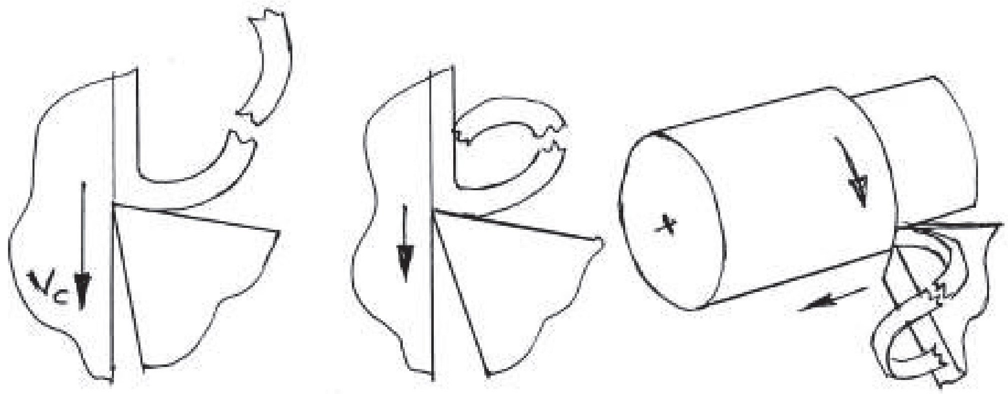
(a) Self breaking of chips

Ductile chips usually become curled or tend to curl (like clock spring) even in machining by tools with flat rake surface due to unequal speed of flow of the chip at its free and generated (rubbed) surfaces and unequal temperature and cooling rate at those two surfaces. With the increase in cutting velocity and rake angle (positive) the radius of curvature increases, which is more dangerous. In case of oblique cutting due to presence of inclination angle, restricted cutting effect etc. the curled chips deviate laterally resulting helical coiling of the chips.

The curled chips may self break:

- By natural fracturing of the strain hardened outgoing chip after sufficient cooling and spring back as indicated in Fig.3.1 (a). This kind of chip breaking is generally observed under the condition close to that which favors formation of jointed or segmented chips.

- By striking against the cutting surface of the job, as shown in Fig. 3.1 (b), mostly under pure orthogonal cutting.
- By striking against the tool flank after each half to full turn as indicated in Fig 3.1(c).



(a) Natural (b) striking on job (c) striking at tool flank

Fig. 3.1 Principles of self breaking of chips.

(b) Forced chip-breaking

The hot continuous chip becomes hard and brittle at a distance from its origin due to work hardening and cooling. If the running chip does not become enough curled and work hardened, it may not break. In that case the running chip is forced to bend or closely curl so that it breaks into pieces at regular intervals. Such broken chips are of regular size and shape depending upon the configuration of the chip breaker.

Chip breakers are basically of two types:

- In-built type
- Clamped or attachment type

In-built breakers are in the form of step or groove at the rake surface near the cutting edges of the tools. Such chip breakers are provided either

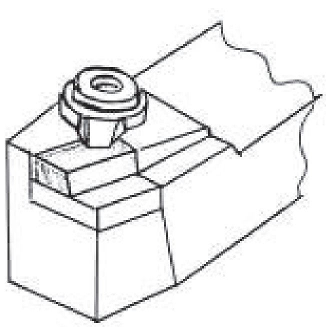
- After their manufacture – in case of HSS tools like drills, milling cutters, broaches etc and brazed type carbide inserts.
- During their manufacture by powder metallurgical process – e.g., throw away type inserts of carbides, ceramics and cermets.

(c) Clamped type chip-breaker

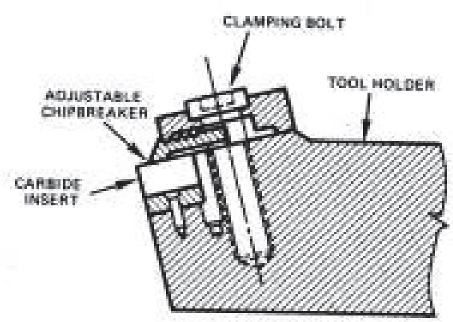
Clamped type chip breakers work basically in the principle of stepped type chip-breaker but have the provision of varying the width of the step and / or the angle of the heel.

Fig. 3.3 schematically shows three such chip breakers of common use:

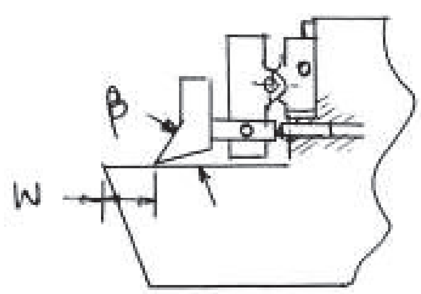
a. With fixed distance and angle of the additional strip – effective only for a limited domain of parametric combination
b. With variable width (W) only – little versatile
c. With variable width (W), height (H) and angle (β) – quite versatile but less rugged and more expensive.



(a) Fixed geometry



(b) variable width



(c) Variable width and angle

Fig. 3.3 Clamped type chip breakers