By Mr. Durga Charan

# WORKSHOP TECHNOLOGY

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| **Unit-1**<br><br>**Introduction to Manufacturing and Metal cutting** | • Definition of manufacturing process, its classification types, primary and secondary manufacturing processes<br>• selection of a manufacturing process, types of production.<br>• Machine Tools; Definition, its functions and classification, introduction to machining operations and common features of metal cutting<br>• Definition and working principle of single point cutting tool, geometry of single point cutting tool, tool signature, orthogonal and oblique cutting<br>• Chips formation, types of chips, Cutting Parameters-Cutting speed, feed and depth of cut. |

## MANUFACTURING PROCESS:

The fundamental goal of manufacturing process is to produce a product that has a useful form. Manufacturing process is one of the important steps in production process. It mainly concerns with the change of form of material or dimensions of the part being produced.

The geometry of the finished product must have certain tolerances, that it must meet in order to be acceptable and being useful.

The three different types of functions that involve in manufacturing process are as follows:

1. To change the physical properties of the raw material.
2. To change the shape and size of the work piece.
3. To produce required dimensional accuracy (tolerances) and surface finish.

## CLASSIFICATION OF MANUFACTURING PROCESS:

Classification of manufacturing process based on nature of work are shown below.

1. To change the physical properties of the materials the following process are performed:

- Hardening
- Tempering
- Annealing
- Surface Hardening.

2. Metal working processes involves the following:

- Rolling,
- forging,
- extrusion,
- wire drawing

3. Machining Processes involves the following:

- Turning,
- drilling,
- milling,
- Grinding

4. Casting Processes involves the following:

- Sand Casting,
- Permanent mould casting,

- die casting,
- Centrifugal casting

5. Joining processes involves the following:
- Welding,
- brazing,
- soldering,
- joining

6. Surface finishing processes involves the following:
- Lapping,
- honing,
- Superfinishing

7. Shearing and Forming processes involves the following:
- Punching,
- blanking,
- drawing,
- bending,
- forming

## PRIMARY AND SECONDARY MANUFACTURING PROCESSES:

### 1. Primary manufacturing processes

These processes are used to convert raw material or scrap to a basic primary shaped and sized product. Such processes cannot provide exactly same product that is desired (unless the required product has very ordinary & simple shape with broad allowance on dimensions). Close dimensional tolerance cannot be achieved by these processes. Achievable surface finish and surface integrity of the products are not very impressive. Appearance of the product is also poor. However, these processes are much useful to give a basic property, shape and size so that it can be further processed in the secondary manufacturing processes. Various primary manufacturing processes are:

- Casting
- Forming, such as Forging, Rolling, Extrusion, etc.
- Joining, such as Welding, Soldering, etc.

### 2. Secondary manufacturing processes

These processes are used to further modify the output of primary manufacturing processes in order to improve the material properties, surface quality, surface integrity, appearance and dimensional tolerance. The input material for these processes must have some specific shape and size; otherwise products may not be accommodated within the machine facility. Various secondary manufacturing processes are:

- Machining
- Surface working, such as Heat Treatment, Coating, etc.

### 3. Advanced manufacturing processes

With the advancement of technology, a number of new methods and technical systems have been developed that can directly convert raw material or scrap into products having close tolerance and dimension, superb surface quality, desired properties and magnificent appearance. Thus, these processes eliminate the need to pass a product through a number of primary and secondary processes; and therefore, production time and cost can be reduced.

Some of these processes are unique and completely different from above two groups; however, others are the developed version of processes from above two groups. Most of these processes use efficient, costlier and precision machines inbuilt with computer control system. The concept of Additive and Subtractive Manufacturing is associated with advanced manufacturing system. Various advanced manufacturing processes are:

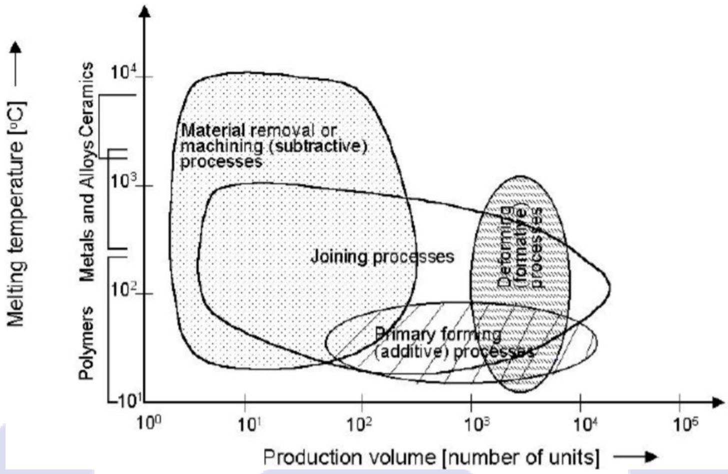
- Powder Metallurgy (PM)
- Rapid Prototyping (RP) or 3-D Printing
- CNC machines, machining centers, etc.
- Dye Casting, etc.

## SELECTION OF A MANUFACTURING PROCESS:

Since, each process works on the different approach for achieving the desired size and shape. Therefore, the mechanical, physical and chemical properties of the material to be processed significantly affect the success of the processing by a particular process or the productivity, which will be associated with a particular process for achieving the desired size and shape. So, what are the factors that we need to consider when a selection is to be made. And of course, what we need first there are two aspects related with the selection, one is the product features which are related with the size, shape, properties, finish, tolerance, soundness or at the acceptance level. So, the product related features are very wide, but as these will be determining how successfully, how effectively product can serve the purpose for which it has been made, but there is another category also which is related with the cost are the economics related with the manufacturing. So, under that only we need to see how it is to be made, so that a product can be made cost effectively in, so that it does not affect to the environment. It is economical and it also serves, it serves the purpose for which it has been made its life is good and so that the purpose of the manufacturing as a whole can be achieved.

So, if we go by the different factors which are associated with the selection of the manufacturing process those which are product based and those which are operational cost or the economics based. So, if we see the shape of the final product, raw material to be processed, the design requirement like features, holes, slots, notches, etcetera to be achieved. The dimensional and the surface properties inform of the size, thickness and the shape complexity which are to be achieved; the tolerance and the finish which is to be achieved, then the properties that are needed in the components like very high strength to weight ratio or very good surface properties, interior properties may not be that a important. So, these are the properties that a we need to consider that we need to achieve in the product which can be made by any of the processes or by combination of the certain processes provided that is achieved at the minimum possible cost, and minimum harm to the environmental conditions.

And for that what we need to see how much design and tooling costs are involved for making a particular product using a process. Because either for casting, forming, machining, welding, heat treatment and super finishing, we need one or other kind of the equipment. So, if that is available it is fine if it is not then we need to make it we need to arrange it, so their costs related to the design and tooling. And then lead time, how much time it will take to get the product, so that after the placement of the order, so that the lead time is a time which is required for getting the delivery of the product after the order is a placed. So, if you have that kind of luxury where long time is available or for certain big customized products long lead time maybe as long as few months to the years also. Then we have the minimizing this scrap, the volume of the production availability of the system which is needed for manufacturing. So, these are the factors related which will be determining the cost at which a given product can be made. And these are the features which will be governing the casting processes in order to realize these pictures in the productive. So, here we will be going one by one through these aspects related with the processes and the product features which can be achieved.




So, if we see the casting wise the casting processes are normally selected for the low melting point metals and for moderate volumes. Then the machining processes these are selected for mostly all formed and cast products are subjected to the machining, primarily for achieving the finish and the tolerance. Primary shaping is not much a done using the machining; and if it is to be done then very limited volumes are used for production purpose of the machining; otherwise mostly machine is used as a secondary a processing, so tolerance.

And then forming processes, forming processes are used for the low yield strength and the high ductility metals and for the high-volume production when the volumes to be made are very large then only this high-volume production processes based on the forming are justified. And the welding is used when welding is used when the desired size and shape cannot be achieved through the primary forming or primary shaping processes like casting and forming. And in that case, we try to use a welding or joining processes, so that the simpler shapes can be brought together to get the desired size and the shape, but there after a frequently the machine is carried out for achieving the desired finish and the tolerance and even in case of the welded joints.

## TYPES OF PRODUCTION SYSTEM:

Production system refers to manufacturing subsystem that includes all functions required to design, produce, distribute and service a manufactured product.
Production system is grouped under two categories:
1. Intermittent Production System
2. Continuous Production System

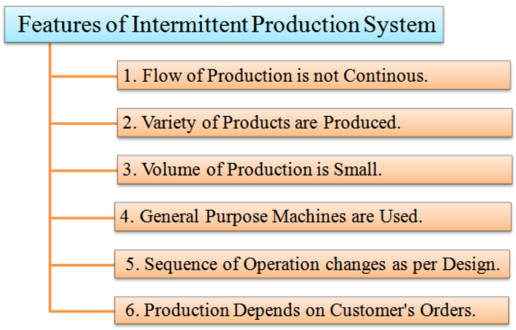
### Intermittent Production System

- Intermittent means something that starts (initiates) and stops (halts) at irregular (unfixed) intervals (time gaps).
- In the intermittent production system, goods are produced based on customer's orders.
- These goods are produced on a small scale.
- The flow of production is not continuous.
- In this system, large varieties of products are produced. These products are of different sizes.

- The design of these products goes on changing according to the design and size of the product. Therefore, this system is very flexible

Examples of Intermittent Production System

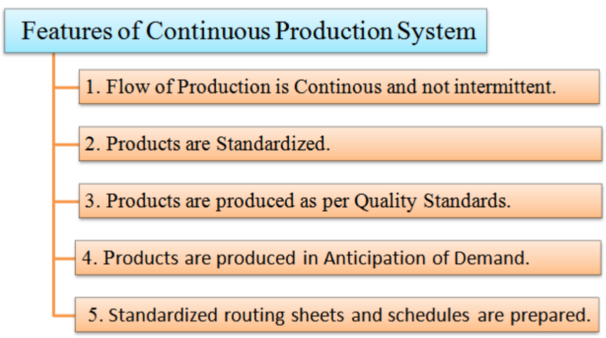
The work of a goldsmith is purely based on the frequency of his customer's orders. The goldsmith makes goods (ornaments) on a smallscale basis as per his customer's requirements. Here, ornaments are not done on a continuous basis.
Similarly, the work of a tailor is also based on the number of orders he gets from his customers. The clothes are stitched for every customer independently by the tailor as per one's measurement and size. Goods (stitched clothes) are made on a limited scale and is proportional to the number of orders received from customers. Here, stitching is not done on a continuous basis.




**Continuous Production System**
Continuous means something that operates constantly without any irregularities or frequent halts.
In the continuous production system, goods are produced constantly as per demand forecast. Goods are produced on a large scale for stocking and selling. They are not produced on customer's orders. Here, the inputs and outputs are standardized along with the production process and sequence.

Examples of Continuous Production System

The production system of a food industry is purely based onthe demand forecast. Here, a large-scale production of food takes place. It is also a continuous production. The production and processing system of a fuel industry is also purely based on, demand forecast. CRUDE OIL and other raw sources are processed continuously on a large scale to yield usable form of fuel and compensate global energy demand.

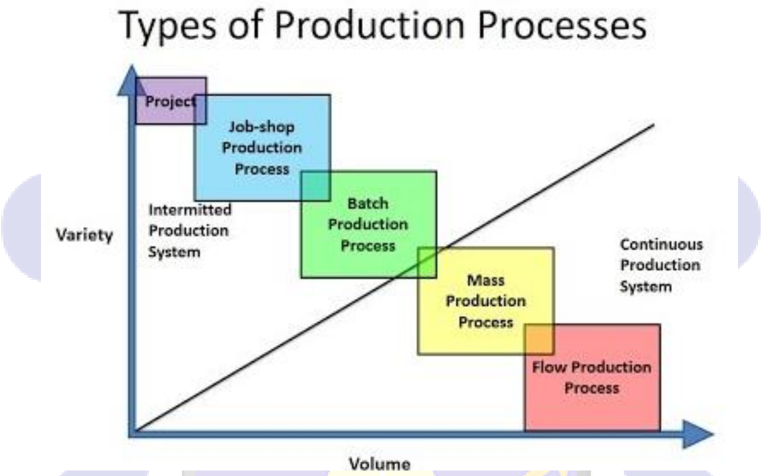


**Types of Intermitted production system**

- Project Production Flow
- Job-shop Production Flow
- Batch Production Flow

**Types of continuous production system**

- Mass production flows
- Process production flows




**1. Project production flows**

Here, in project production flows, company accepts a single, complex order or contract. The order must be completed within a given period of time and at an estimated cost. Examples of project production flows mainly include, construction of airports, dams, roads, buildings, shipbuilding, etc.

**2. Job-Shop production flows**

Here, in job-shop production flows, company accepts a contract to produce either one or few units of a product strictly as per specifications given by the customer. The product is produced within a given period and at a fixed cost. This cost is fixed at the time of signing the contract. Examples of such jobbing production flows include, services given by repair shops, tailoring shops, manufacturer of special machine tools, etc.

**3. Batch production flows**

In batch production flows, the production schedule is decided according to specific orders or are based on the demand forecasts. Here, the production of items takes place in lots or batches. A product
is divided into different jobs. All jobs of one batch of production must be completed before starting the next batch of production. Examples of batch production flows include, manufacturing of drugs
and pharmaceuticals, medium and heavy machineries, etc.

**4. Mass production flows**

Here, company produces different types of products on a largescale and stock them in warehouses until they are demanded in the market. The goods are produced either with the help of a single operation or uses a series of operations. E.g. of mass production is the production of toothpastes, soaps, pens, etc.

**5. Process production flows**

Here, a single product is produced and stocked in warehouses until it is demanded in the market. The flexibility of these plants is almost zero because only one product can be produced. Examples of these plants include, steel, cement, paper, sugar, etc

## 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.

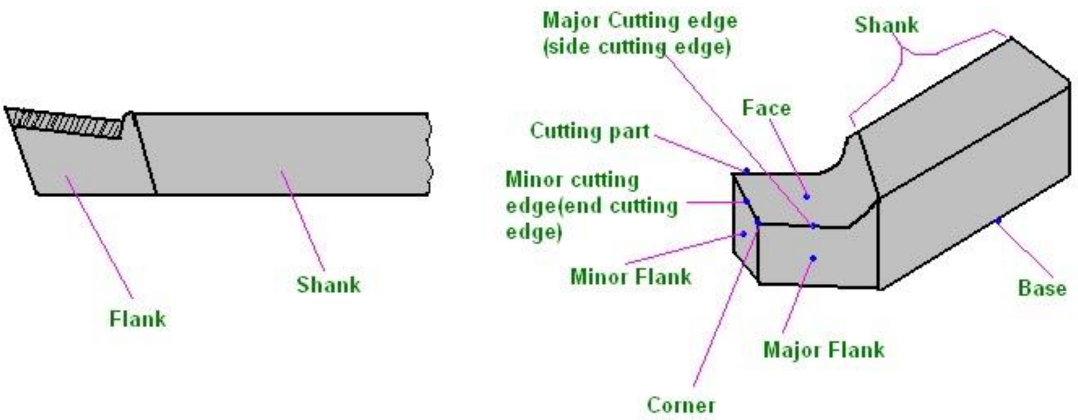
### Machining

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.

## 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. It is generally used in the lathe machine, shaper machine etc. It is used to remove the materials from the workpiece.

**Nomenclature of single point cutting tool:**




### Terms and definitions

**1. 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.

**2. 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.

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

**4. 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.

**5. 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.

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

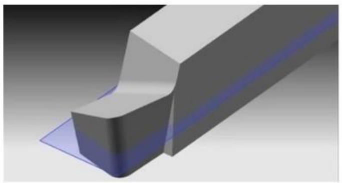
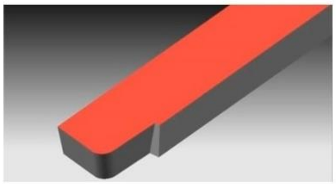
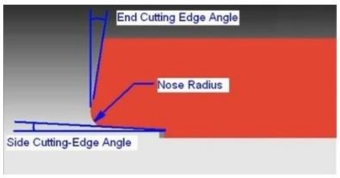
**7. Nose radius:** It is the radius of the nose. Nose radius increases the life of the tool and provides better surface finish.

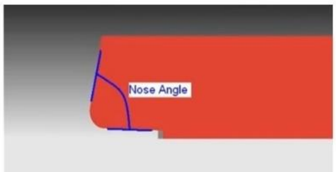
**8. Heel:** It is a curved portion and intersection of the base and flank of the tool.

## Angles of Single Point Cutting Tool

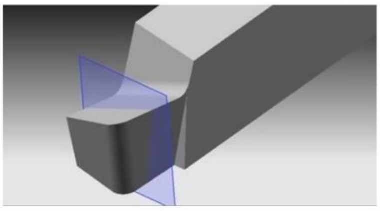
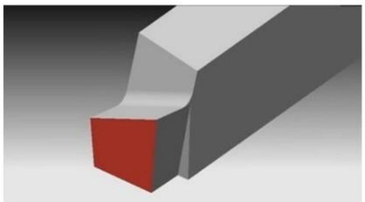
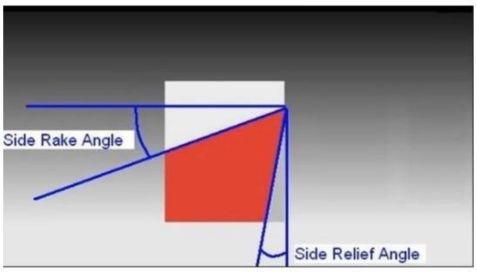
The various angles of the single point cutting tool have great importance. Each angle has its own function and speciality.

1. **End Cutting Edge Angle:** The angle formed in between the end cutting edge and a line perpendicular to the shank is called end cutting edge angle.
2. **Side Cutting Edge Angle:** The angle formed in between the side cutting edge and a line parallel to the shank.

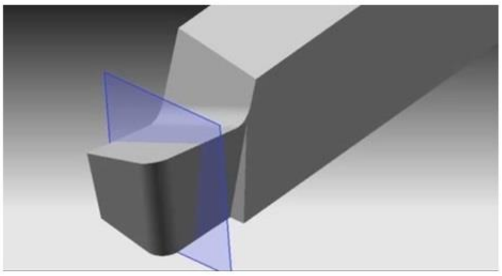




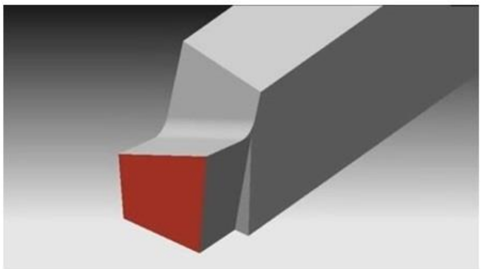


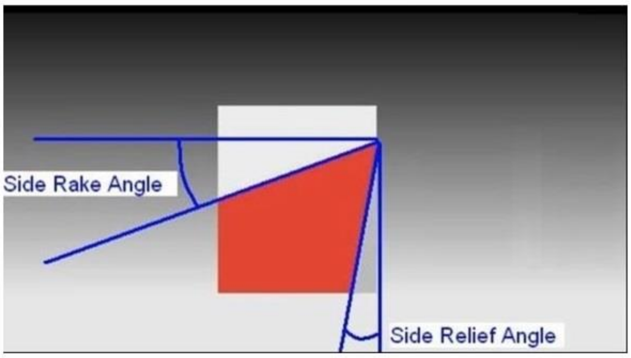

**3. Back Rack Angle:** The angle formed between the tool face and line parallel to the base is called back rake angle.
**4. End Relief Angle:** The angle formed between the minor flank and a line normal to the base of the tool is called end relief angle. It is also known as front clearance angle. It avoid the rubbing of the workpiece against tool.
**5. Lip Angle/ Wedge Angle:** It is defined as the angle between face and minor flank of the single point cutting tool.

**6. Side Rake Angle:** the angle formed between the tool face and a line perpendicular to the shank is called side rake angle.
**7. Side Relief Angle:** the angle formed between the major flank surface and plane normal to the base of the tool is called side relief angle. This angle avoids the rubbing between workpiece and flank when the tool is fed longitudinally.

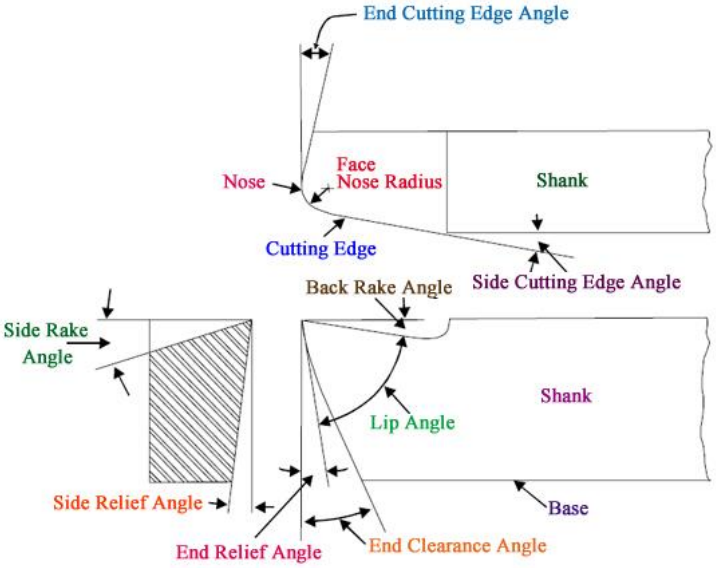







## TOOL SIGNATURE OF SINGLE POINT CUTTING TOOL

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
1. American Standard Association (ASA)
2. Orthogonal Rake System (ORS) or International system



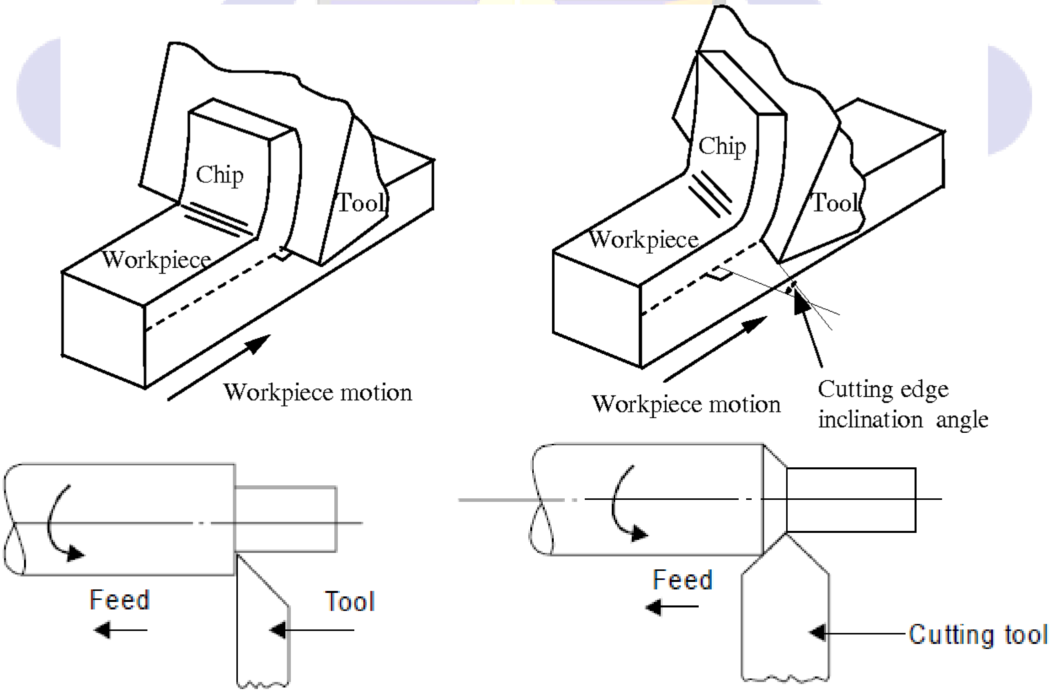

NOMENCLATURE OF SINGLE POINT CUTTING TOOL

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**

## 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. 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.




Orthognal cutting    Oblique cutting

## TYPES OF CHIPS IN METAL CUTTING

During machining the excess material removes from work piece in form of chips.
The chips types are depending 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.

**Types of chips**

Chips formation is part of machining process. It is form during cut the work piece by some of mechanical means. The chips depend on the material of work piece and tool and cutting condition. There are mainly three chips types.

**1. Continuous chips:**

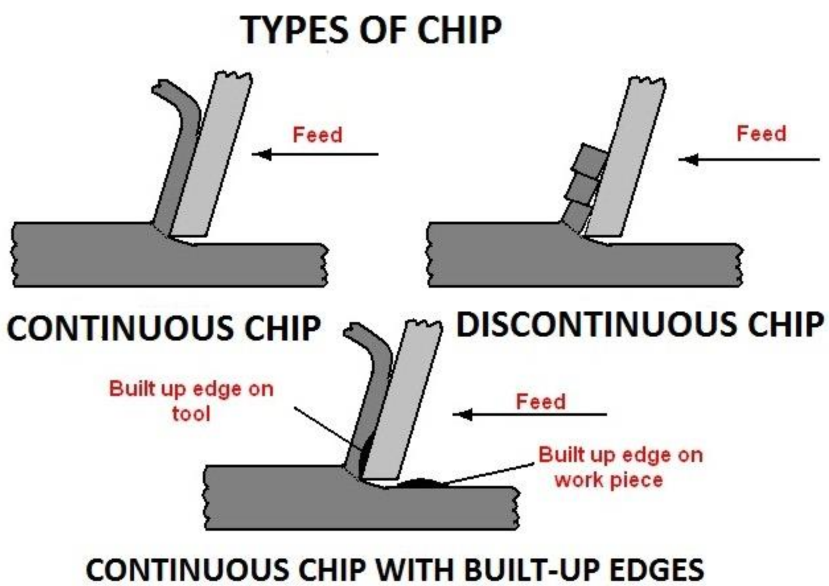
According to its name, continuous chips have a continuous segment. This chip is form during cutting of ductile material like aluminum, mild steal, cooper etc. with a high cutting speed. The friction between tool and material is minimum during this process. This is form due to continuous plastic deformation 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

1. Work piece should have ductile in nature.
2. The rack angle should be large.
3. Friction between work piece and tool should minimum.
4. Cutting speed should high.
5. Deft of cut should be small.
6. Proper use of coolant and lubricant.
7. Tool should have low coefficient of friction.

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

1. It gives high surface finish of machining ductile material.
2. Continuous chips form when low friction which minimize friction loss.
3. Due to low friction, tool life is high
4. Power consumption is low.



**2. Discontinuous chips or segmental chips:**
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 favourable conditions of forming this type of chip are
1. The work piece should have brittle in nature.
2. Slow speed of cutting
3. Small rack angle of tool
4. Depth of cut should large

**3. Continuous Chips with built up edge:**
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.
The common factors promoting built up edge are
1. Cutting of ductile metal.
2. High friction force at the face of tool.
3. High temperature between tool and work piece.
4. Lack of coolant and lubricant

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

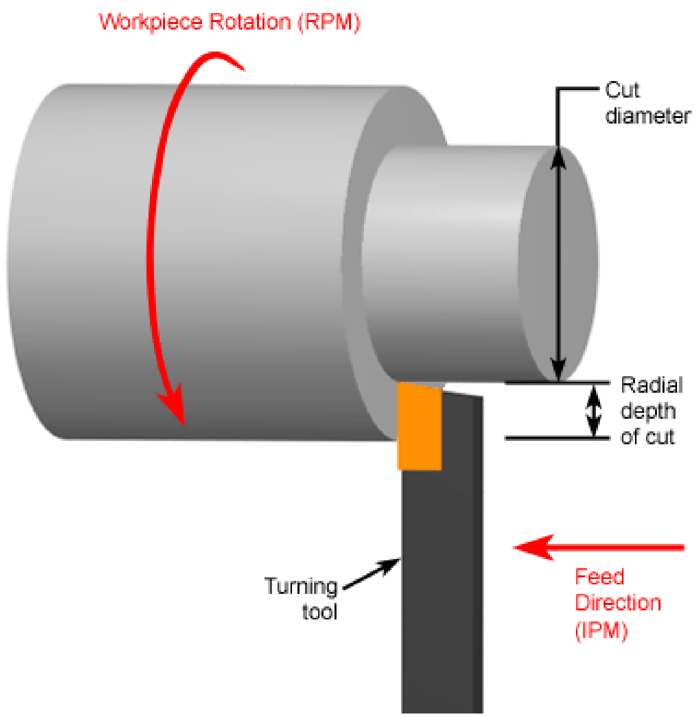
| **S. No.** | **Material type** | **Rack angle** | **Depth of cut** | **Cutting speed** |
|---|---|---|---|---|
| Continuous Chips | Ductile | High | Small | Large/medium |
| Discontinuous Chips | Brittle, Ductile but hard | Medium | High | Low |
| Continuous chips with built edge | Ductile | Low/Medium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

## CUTTING PARAMETERS

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

**Cutting Speed (V):**
It is the speed at which the metal is removed by the cutting tool from the workpiece. In case of lathe machine cutting speed is the peripheral speed of the work past the cutting tool. It is expressed in meter/min. or mm/min.

**Feed rate (f):**
It is the relative motion of tool in one revolution of workpiece. It is expressed in mm/rev.




**Depth of Cut (t):**
It is the total amount of metal removed per pass of the cutting tool. It is expressed in mm. It can vary and depending upon the type of tool and work material. Mathematically, it is half of difference of diameters.