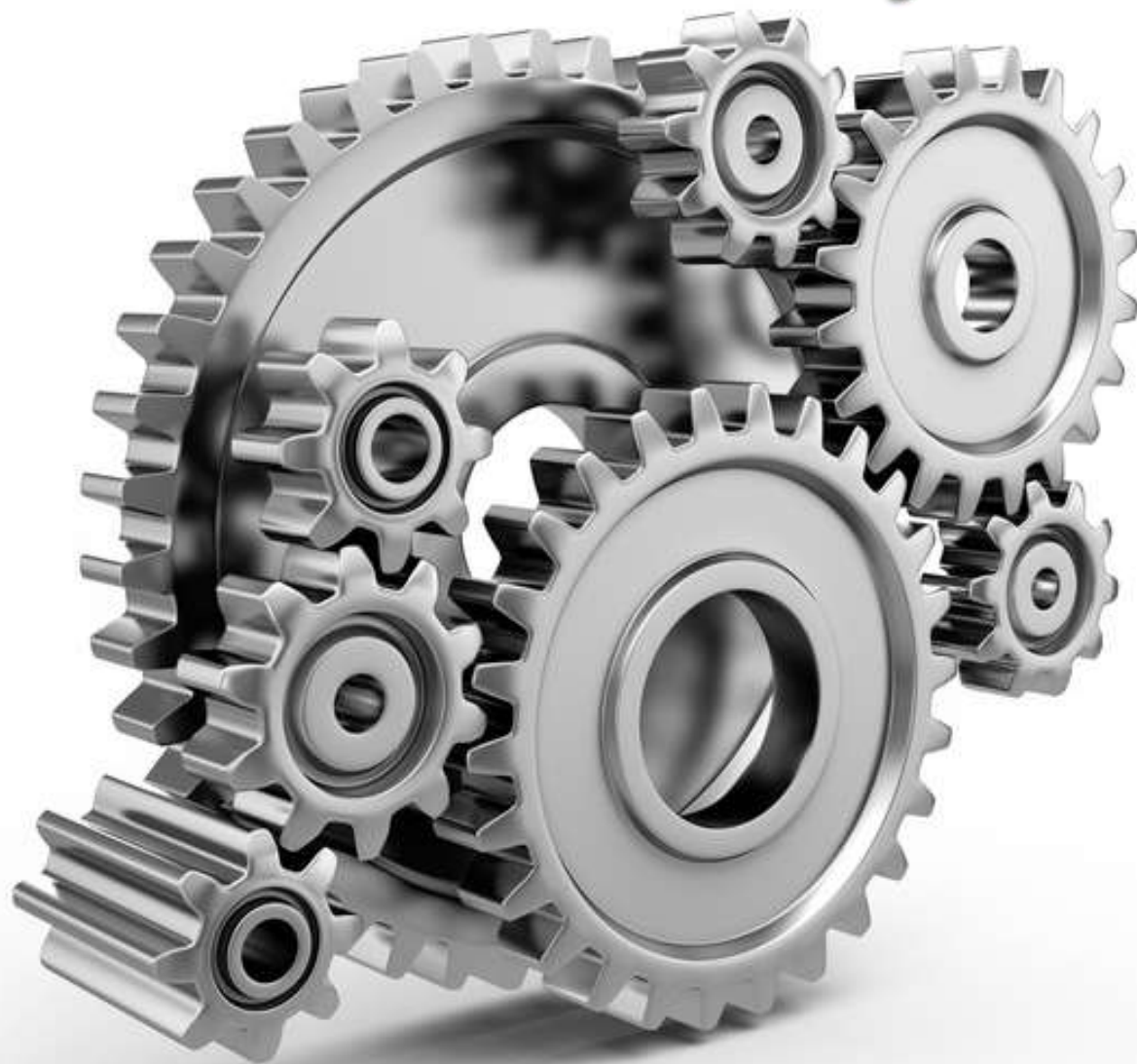
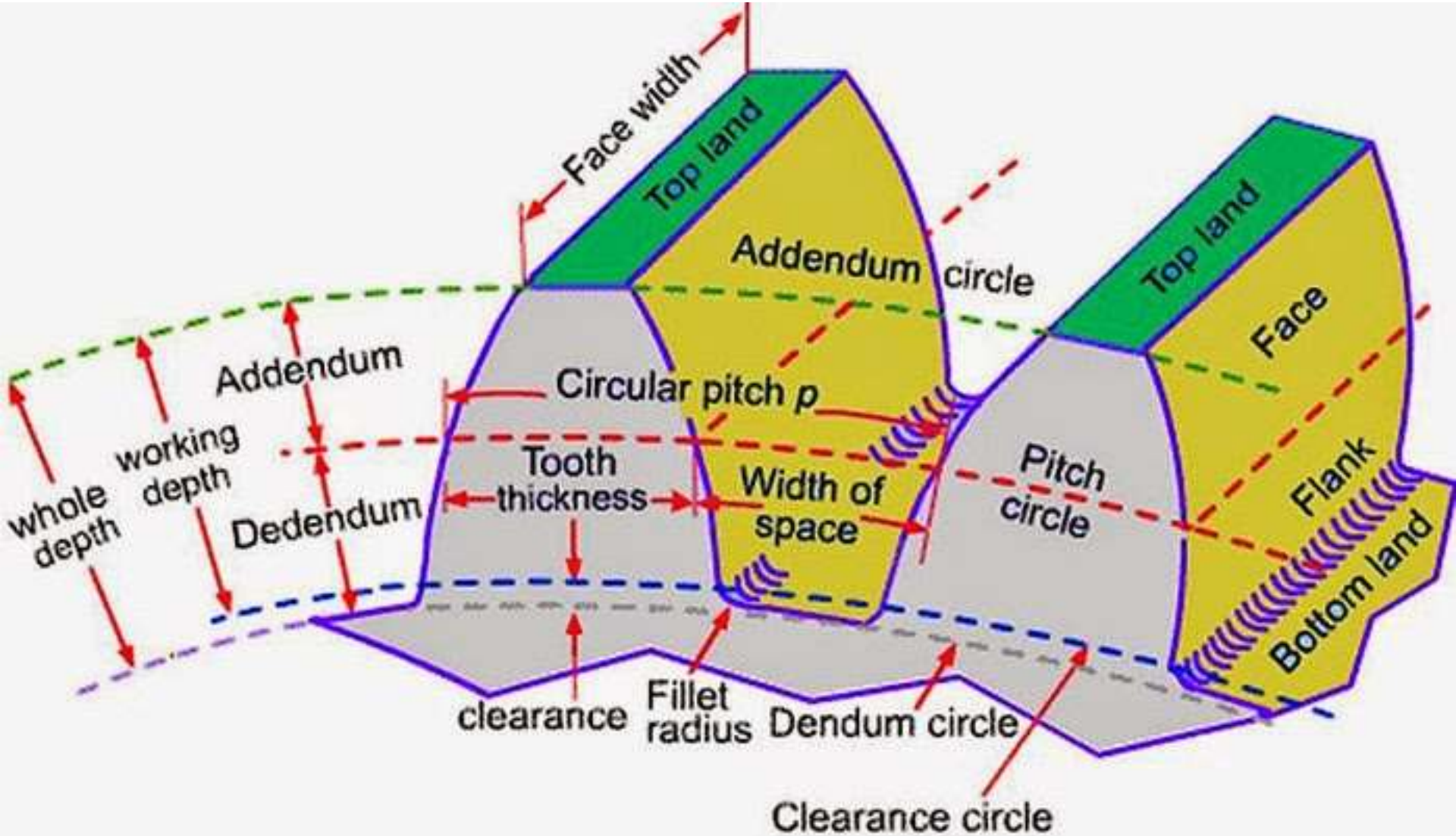


# CHAPTER # 3

## *Gear and Thread Manufacturing*



# Gear Terminology:



# Methods of manufacturing gears:

1. Casting
2. Metal Forming
3. Powder metallurgy
4. Metal removal

## Casting:

- Cast in sand mould, permanent mould, shell mould, plastic mould and wax mould.
- Heavy gears of CI are generally made by sand casting.
- Poor accuracy .
- Used in slow speed drive.
- Investment casting can produce accurate gears
- Have more strength.
- Advantage of casting is low cost production.

# Metal Forming:

- Roll forming
- Extrusion
- Stamping
- Coining

## Roll forming :

- Gears are made by forcing a hardened master gear into a gear blank mounted on shaft.
- Master gear fed inward gradually.
- Done both hot and cold forming.
- Large deformation is possible in hot forming, finishing can be done by cold forming.
- Cold forming requires high pressure compared to hot forming.
- Method can be called chip-less method, Material saving.

# Metal Forming:

contd...

## Extrusion:

- Metal bar is extruded through several block dies with the final die having the shape of the desired tooth element.
- Material can finally be extruded to obtain gear on surface of bar.
- Extruded gear bar is then hacksawed.
- Only spur gears are manufactured by this method.
- Gear used in watches.

# Metal Forming:

contd...

## Stamping:

- Sheet metals gears.
- Up to 3 mm thickness.
- Used in toys, watches, domestic appliances.

## Coining:

- Gears coined from blanks in a hydraulic press or forging hammer.
- Gear required light machining.



## Powder metallurgy:

- Metal powder is pressed in dies conforming to the tooth shape.
- Sintering is done.
- Coined to increase density and surface finish.
- High quality gears.
- Small gears upto 25 mm diameter.
- CI, Steel, Brass and others alloys.

# Metal Removal:

contd...

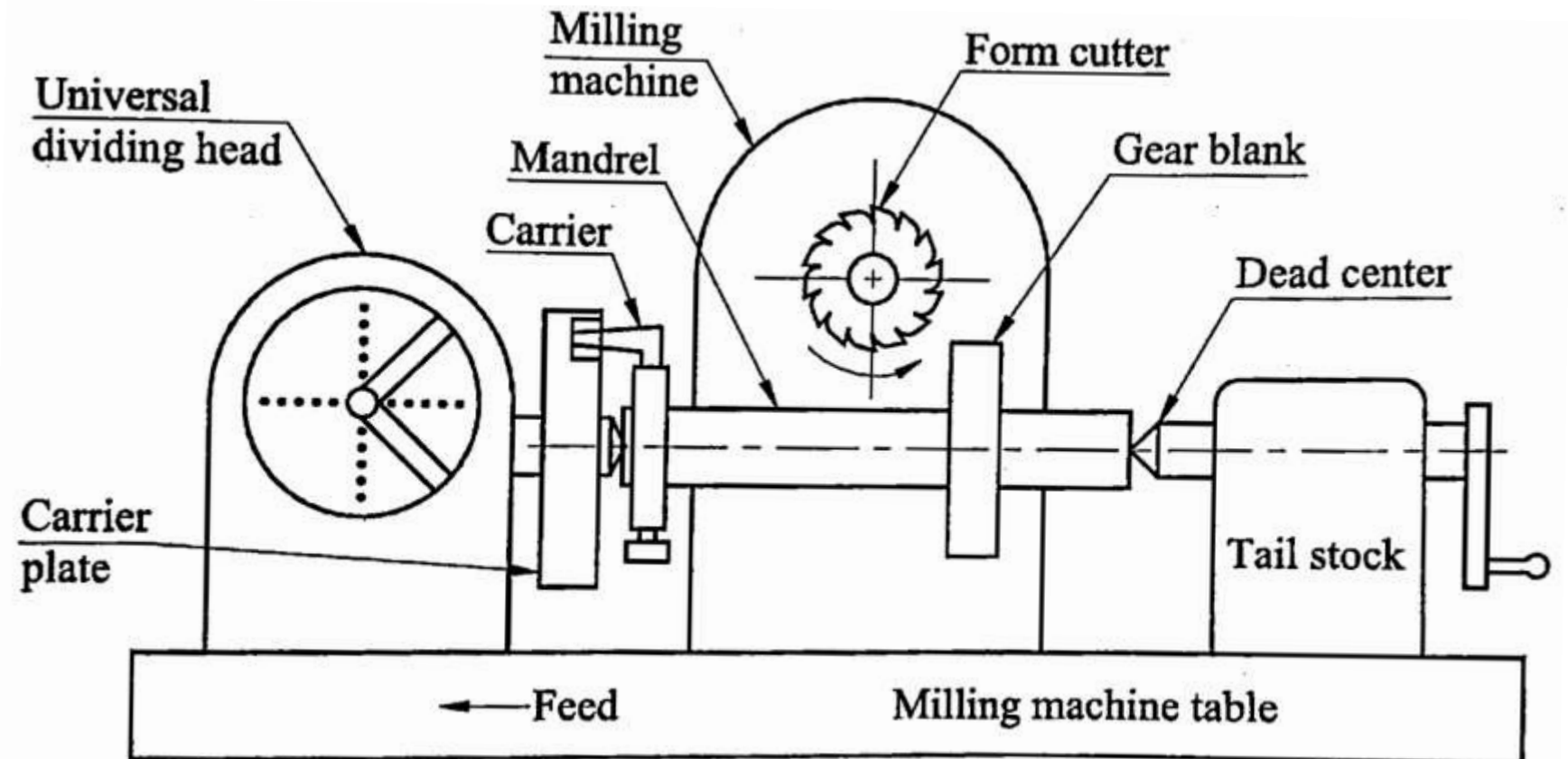
- Widely used method of producing gears.

## Forming or profiling

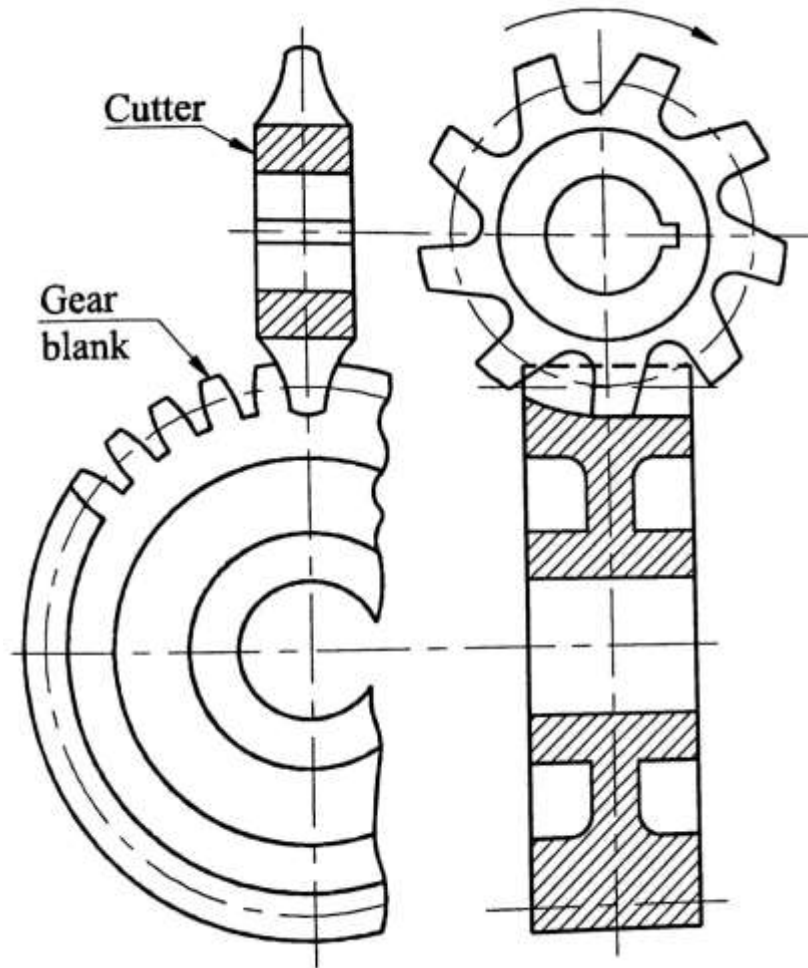
- Cutter used has the same as form as the space between the teeth to be cut.
- Requires the use of special cutter for each application.
  1. Gear cutting on milling machine with formed disc cutter or end-milling cutter.
  2. Gear cutting on planer or shaper with single point formed tool.
  3. Gear cutting with formed cutter in broaching machine.

# 1. Gear cutting by milling with form cutters:

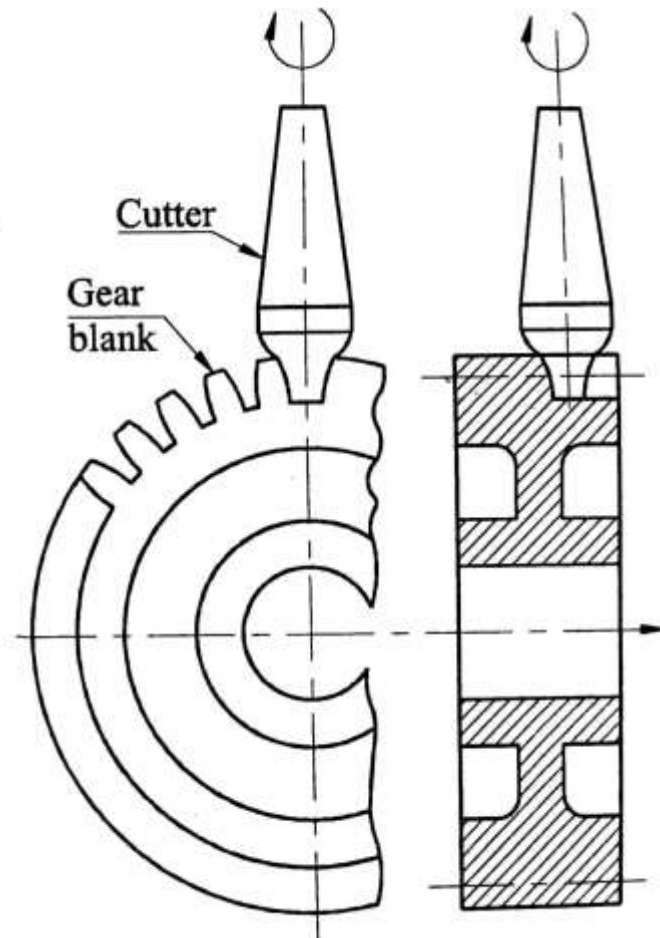
- Milling machines are capable of cutting practically every type of gear by employing an universal indexing mechanism and a form cutter.



# 1. Gear cutting by milling with form cutters: contd...

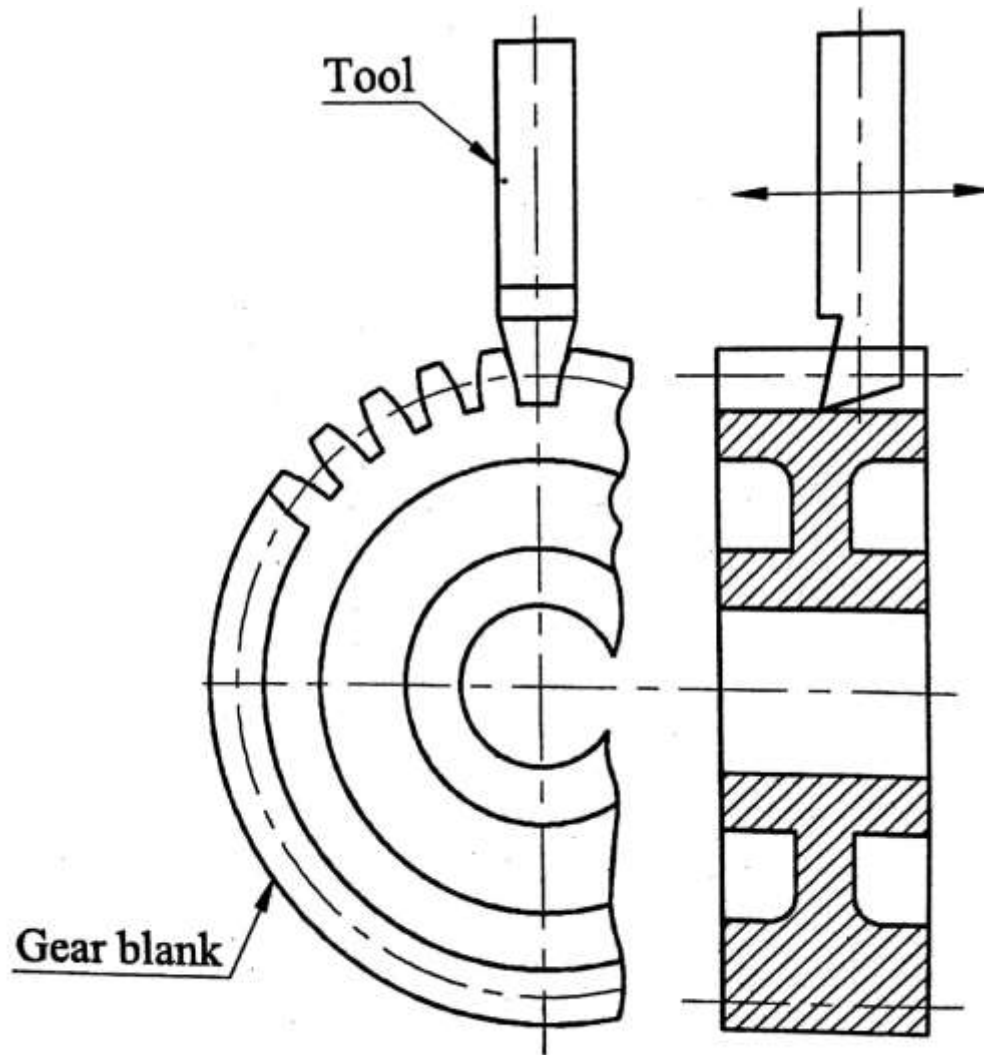


[Disc type form cutter]



[End mill cutter]

## 2. Gear cutting with single point formed tool on shaper/planer:



### 3. Broaching:

- Both internal and external gears can be manufactured using a form tool called broach.
- Broach should carry teeth which conform in shape to the profile of the tooth space of the gear to be cut.
- Teeth cut on the gear carry superior finish.
- Favorable process for cutting internal gears.

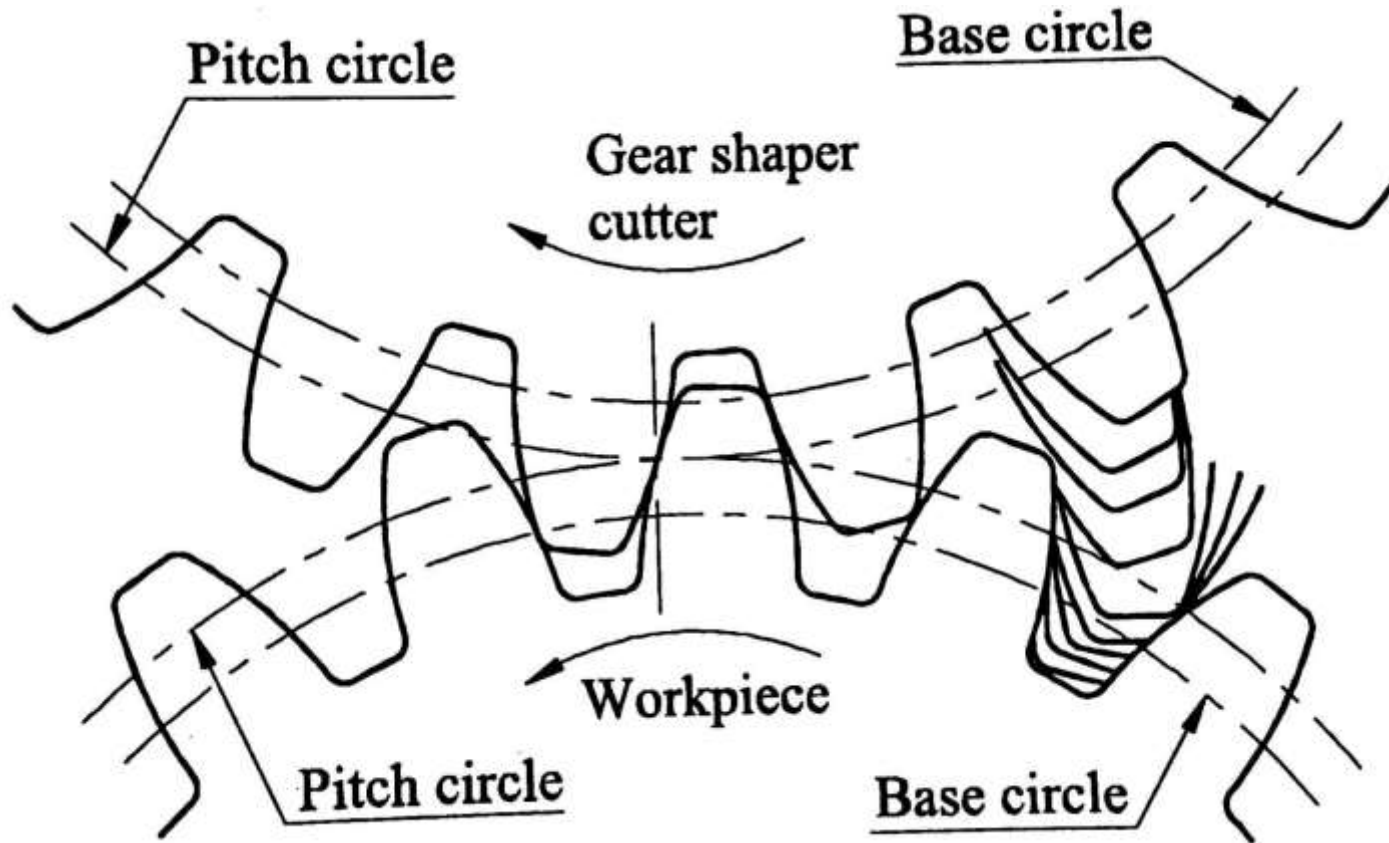
## Gear generation

- One of the gears on the rack is made into a cutter by proper sharpening.
- This cutter gear meshes with the gear blank.
- Teeth on blank are developed or generated by relative rolling motion of the cutter and the blank.
- Same cutter of a particular module can cut gears of different number of teeth without profile deviation.
- Can be used for mass production.

# 1. Gear shaping:

contd...

- Cutter is a gear provided with cutting edge.

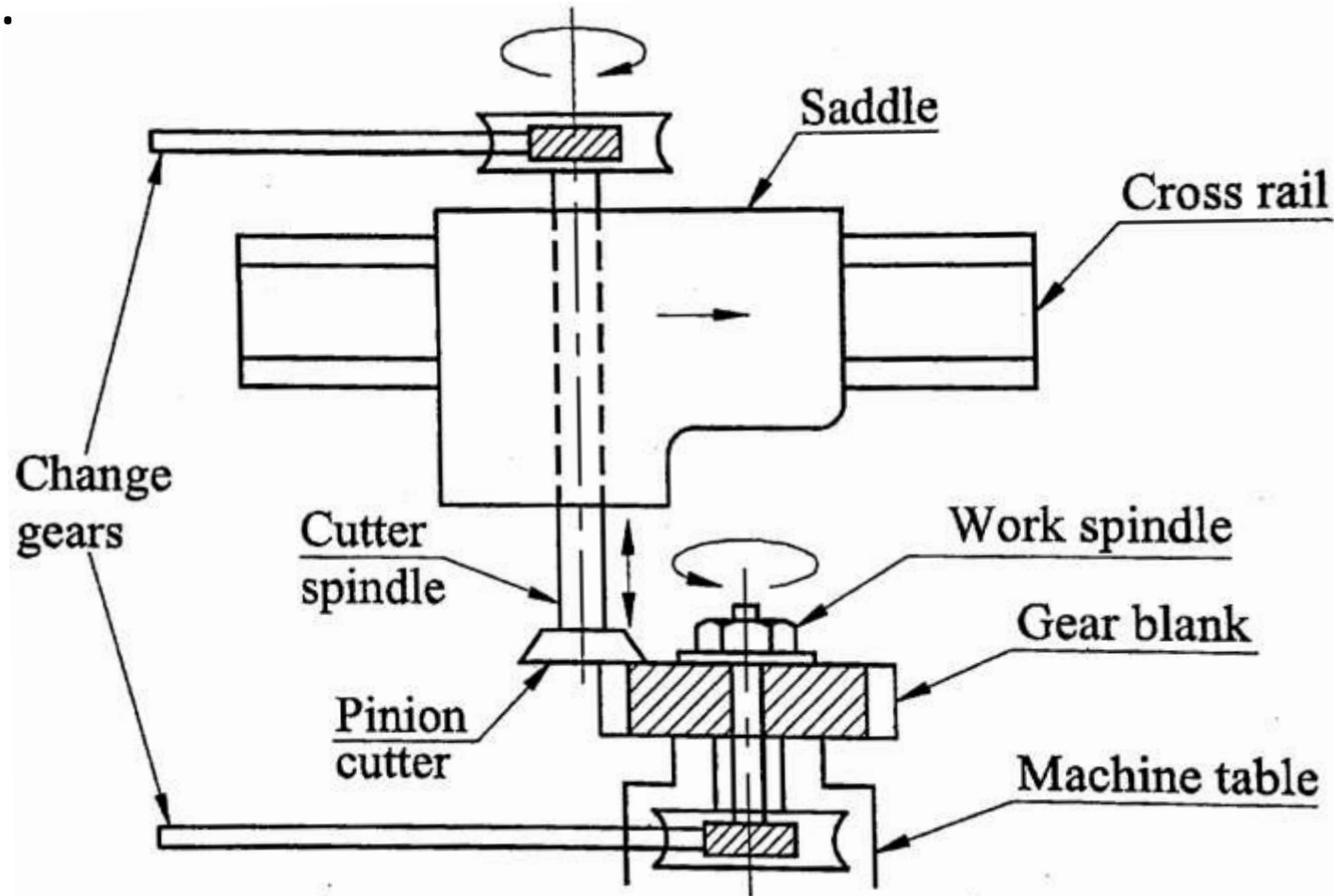




# 1. Gear shaping:

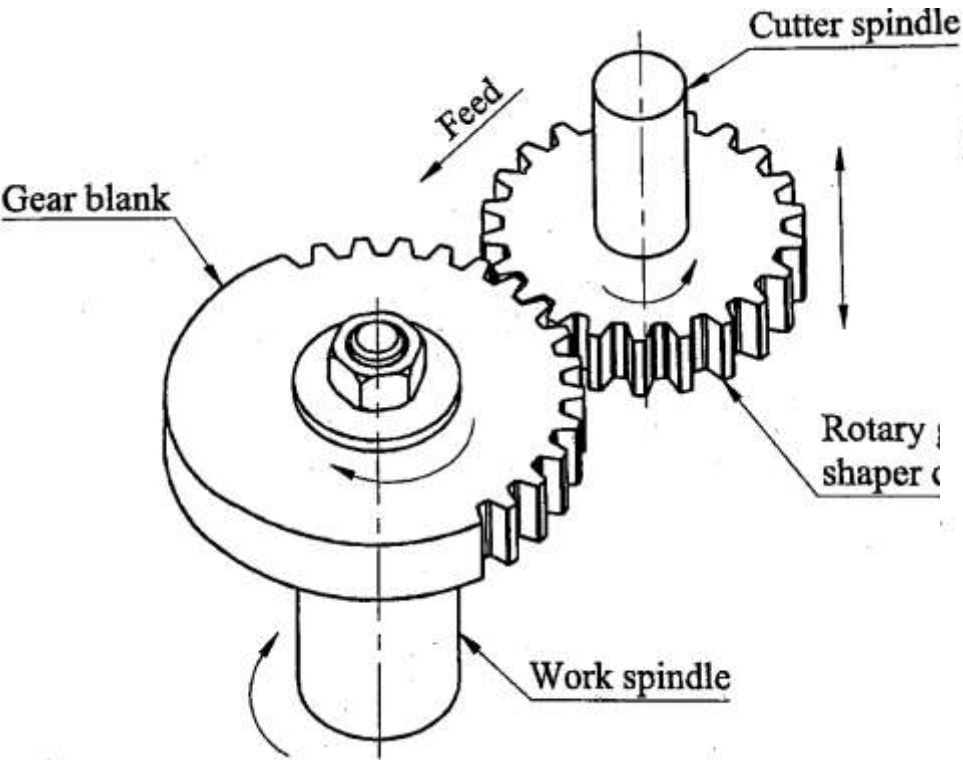
contd...

- Cutter is mounted with its axis vertical and reciprocate.
- Cutter and gear blank both rotate slowly about their own axis.

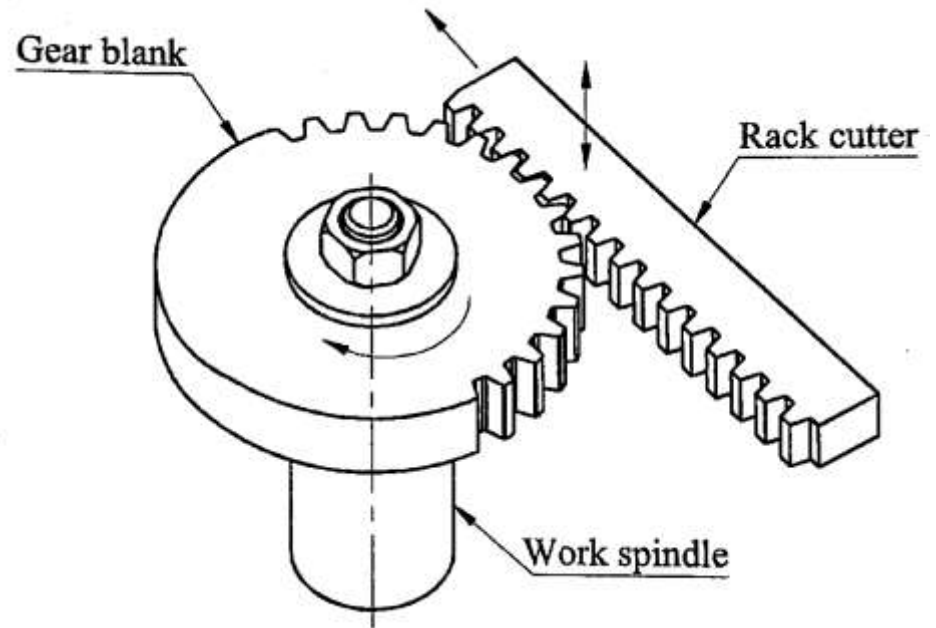


# 1. Gear shaping:

contd...



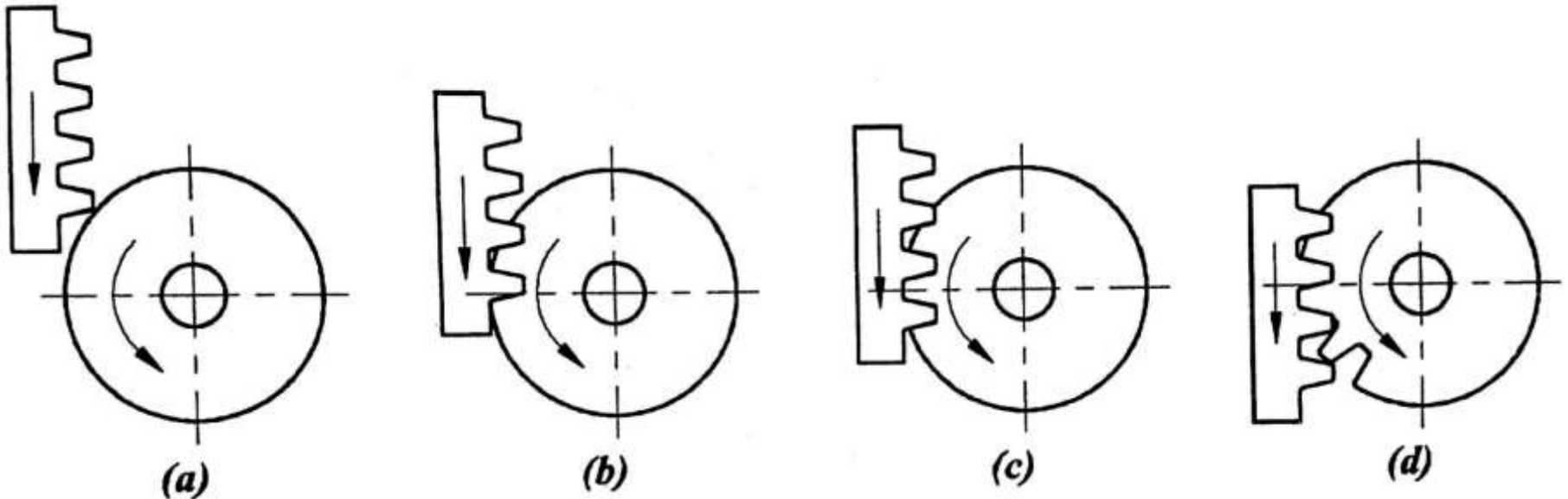
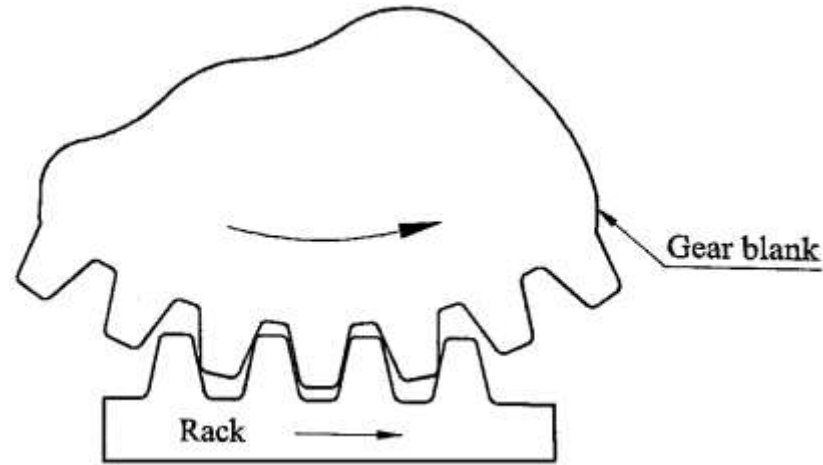
[Rotary shaper cutter]



[Rack type shaper cutter]

## 2. Gear planing:

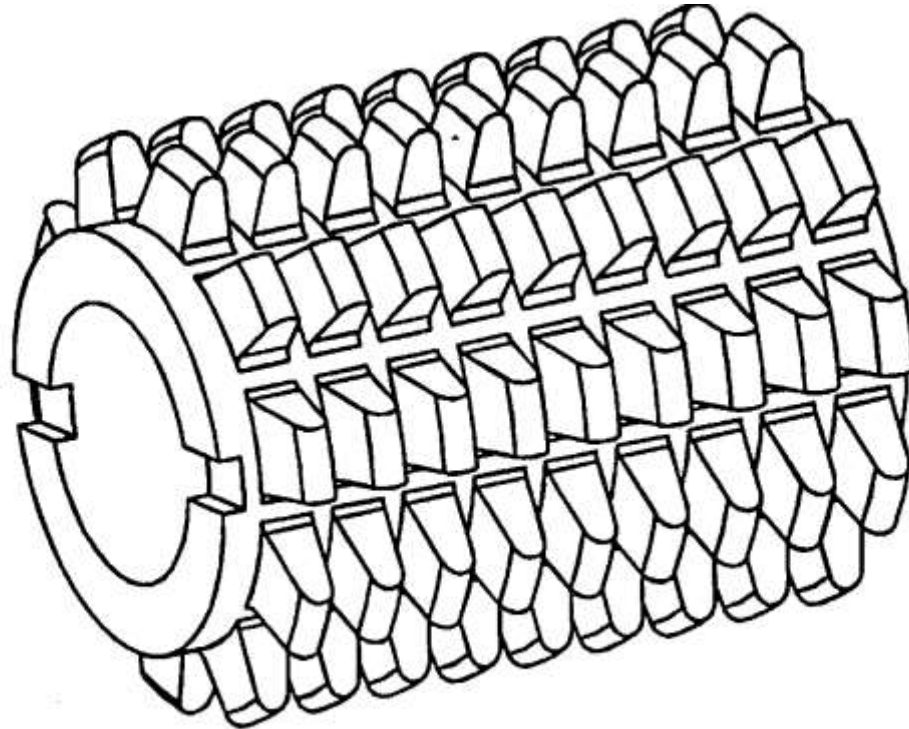
- Generating spur gear and heliacal gear with the help of rack type cutter.



### 3. Gear hobbing:

contd...

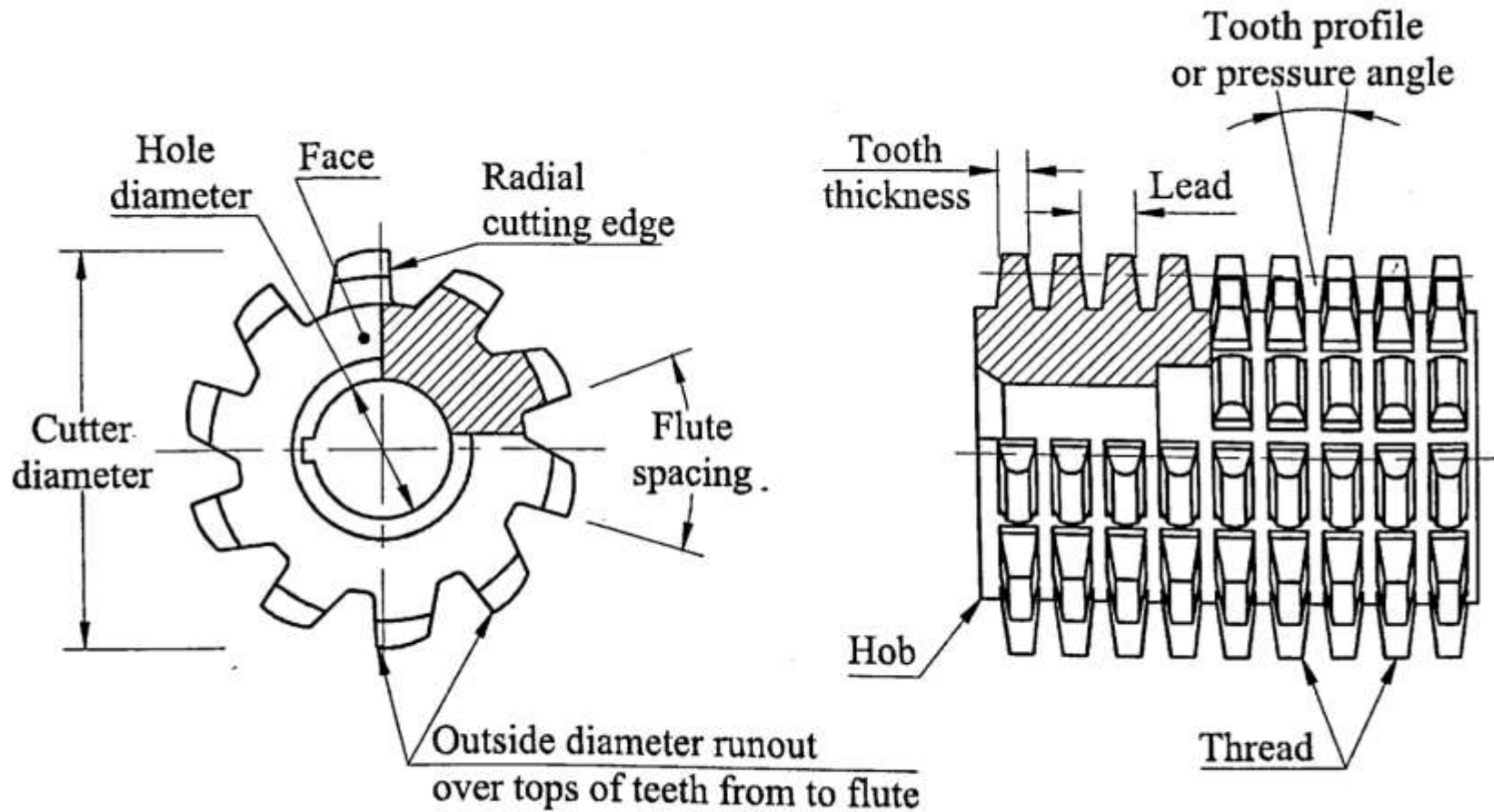
- Fastest of the gear generating processes.



*(a) Hob*

# 3. Gear hobbing:

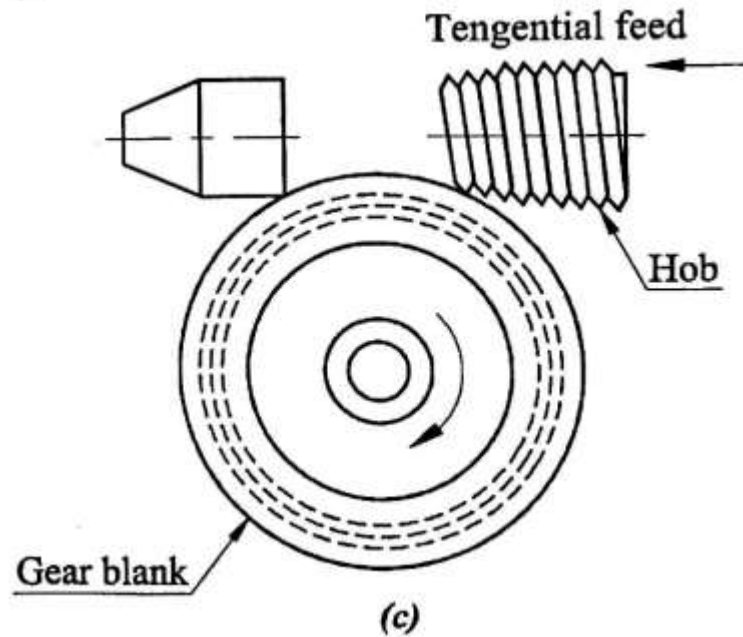
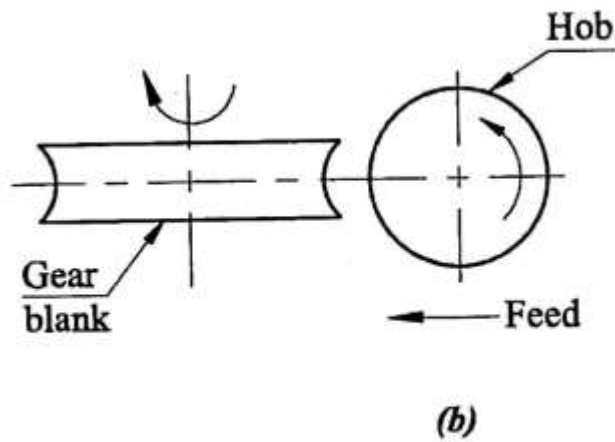
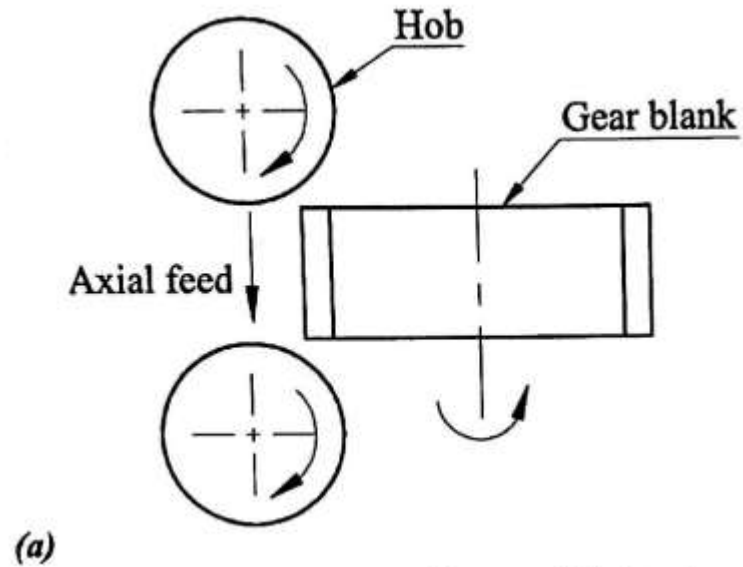
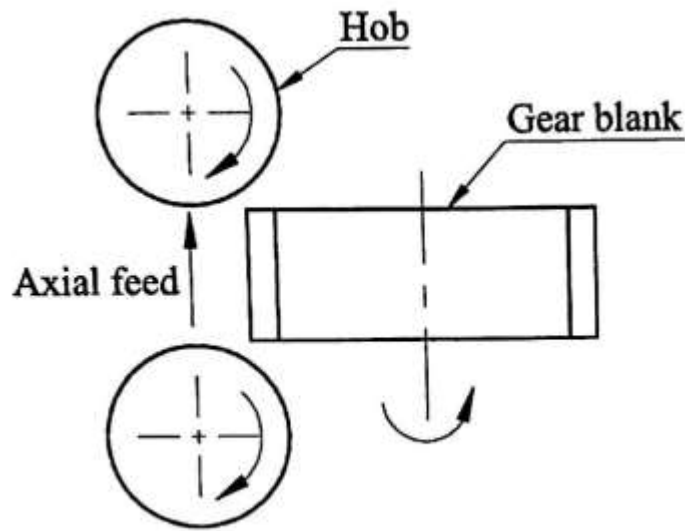
contd...



*(b) Elements of hob*

# 3. Gear hobbing:

contd...



## Gear finishing process:

- The surface of gear teeth produced through forming or generation process is not very accurate and properly finished.
- Results in noise, excessive wear, backlash among meshing teeth or sometime in ultimate failure of the gear in the drive.
- To overcome these defects, some finishing operations become necessary after the gears are produced.
- It makes gear quite and smooth during running.

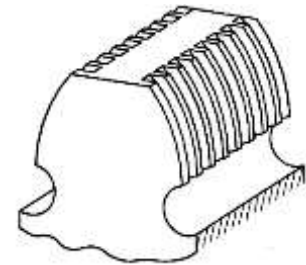
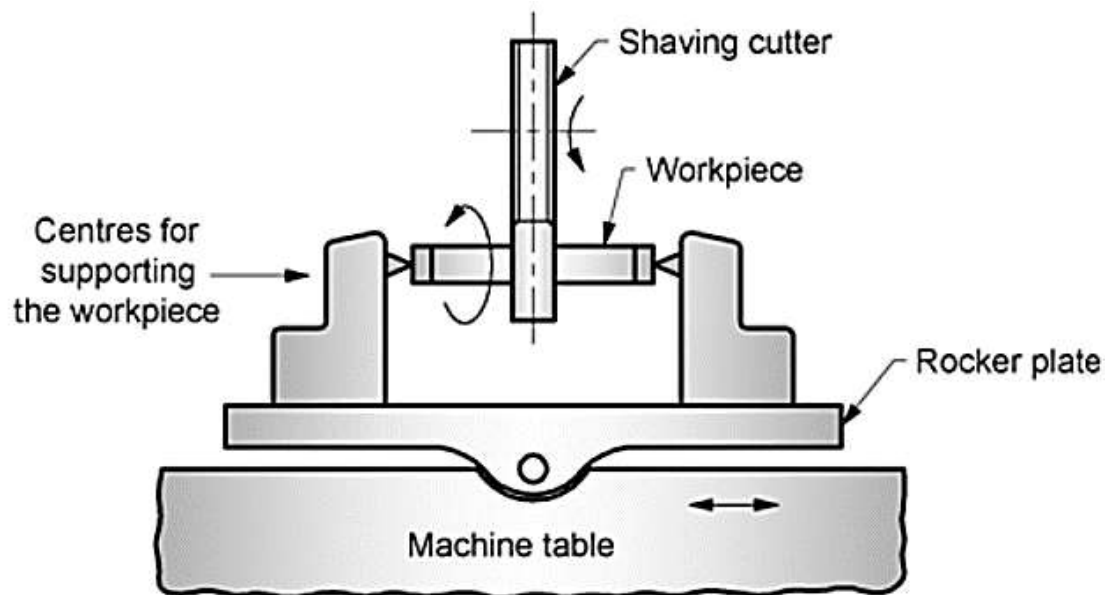


# Gear finishing process:

contd...

## 1. Gear shaving:

- Gear run at high speed in mesh and pressed against a hardened gear shaving cutter.
- Sharp edges of the shaving cutter scrape small amount of metal from the surface of the teeth removes surface irregularities.





# Gear finishing process:

contd...

## 2. Gear burnishing:

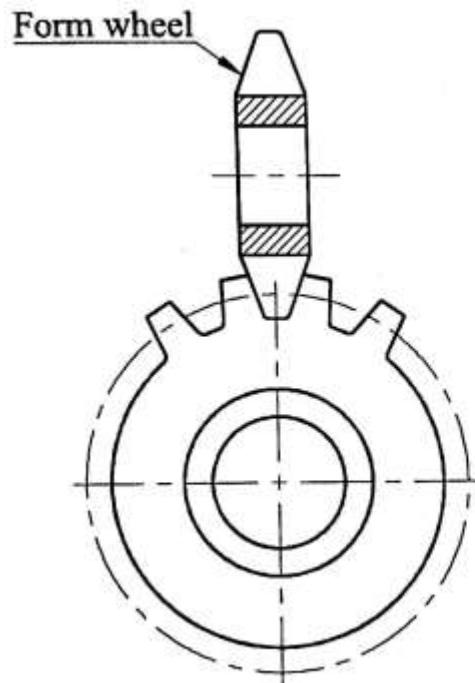
- Done before hardening of gears.
- Work gear rolled under pressure, with hardened and accurately finished gear.
- Excessive material from non-desired regions is plastically moved out by rolling action.
- Though the method provides smooth and accurate tooth profile, it increases localized residual stresses.
- Never advisable to employ the method on precision gears.

# Gear finishing process:

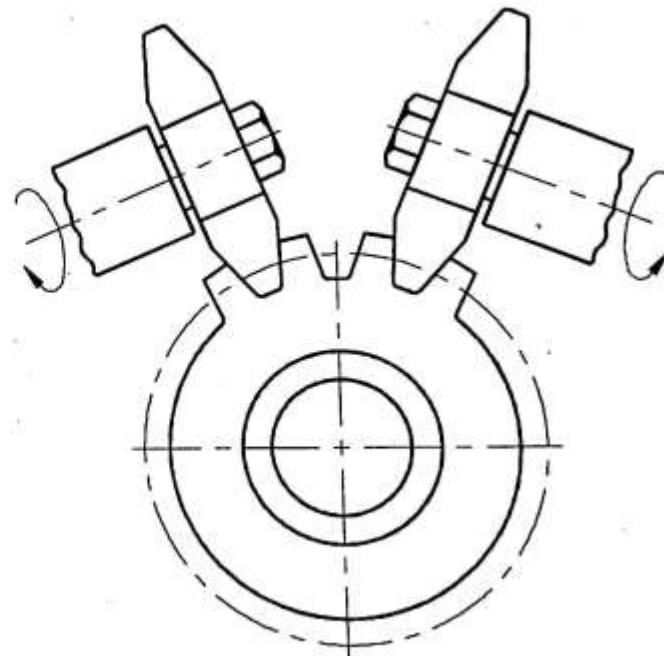
contd...

## 3. Gear grinding:

- Most accurate method of finishing gear teeth.
- Method is slower and more expensive but it gives highest quality gears.



(a) *Form wheel grinding*



(b) *Generation grinding*

## 4. Gear lapping:

- Lapping is often done on hardened gears (Hardness, > 45RC) to remove burrs, scales, abrasions, nicks and irregularities from the surface and to remove small errors caused by heat treatment.
- It is carried out by running the work gear in mesh with a mating gear or one or more small cast iron toothed laps under a flow of fine abrasives in oil.
- During lapping the work is turned first in one direction and then in the other to finish both sides of the tooth.
- Very small amount of material is removed during lapping.

## 5. Gear honing:

- Like lapping, honing is also suitable for finishing heat treated gears.
- It is carried out with the help of steel tools having abrasive or cemented carbide particles embedded in their surface.
- The honing tool is pushed with constant force along the tooth space.
- The honing tools are costlier than lapping tools but the process is much faster.

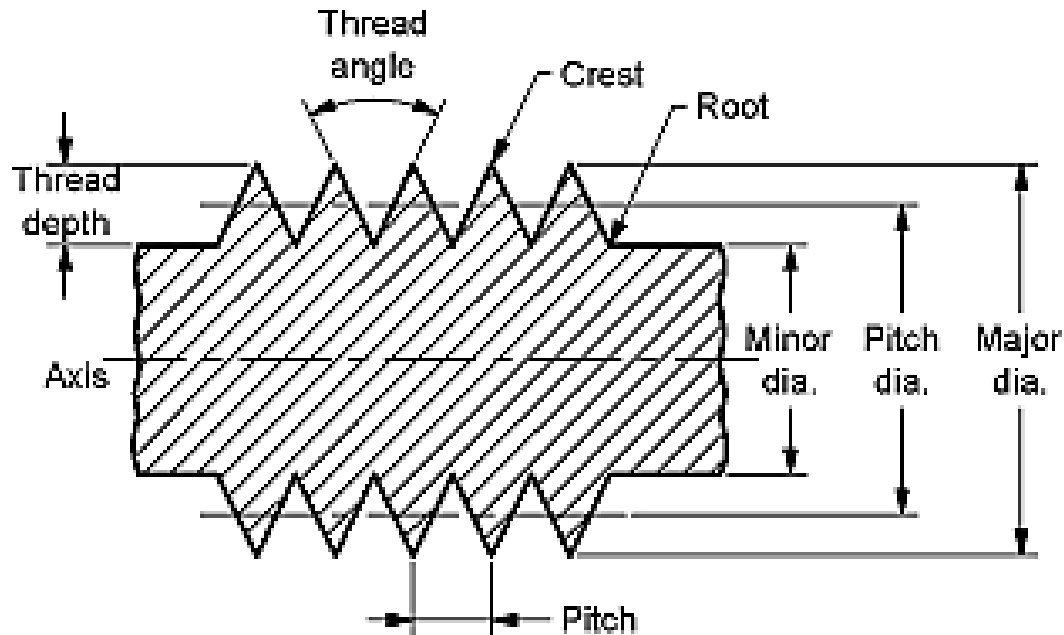


# Thread Manufacturing



# Thread :

- A screw thread is a ridge of uniform cross section in the form of a helix provided on the outside or inside of a cylindrical or conical surface.



- External threads are provided on bolts, screws and studs while internal threads are necessary on the corresponding nuts or machine members into which these units are to be screwed.

## Applications of Thread :

- Functionally threads serve many purposes. Bolts, studs, screws and other fasteners are threaded for holding components securely yet permitting them to be separated whenever desired.
- Screw jacks and presses are provided with threaded components for transmitting power.
- Lead screws in machine tools facilitate controlled accurate movements.
- Accurately cut screws in dividing machines, micrometers and other measuring devices are used to control and measure fine dimensions.

# Thread Manufacturing Methods:

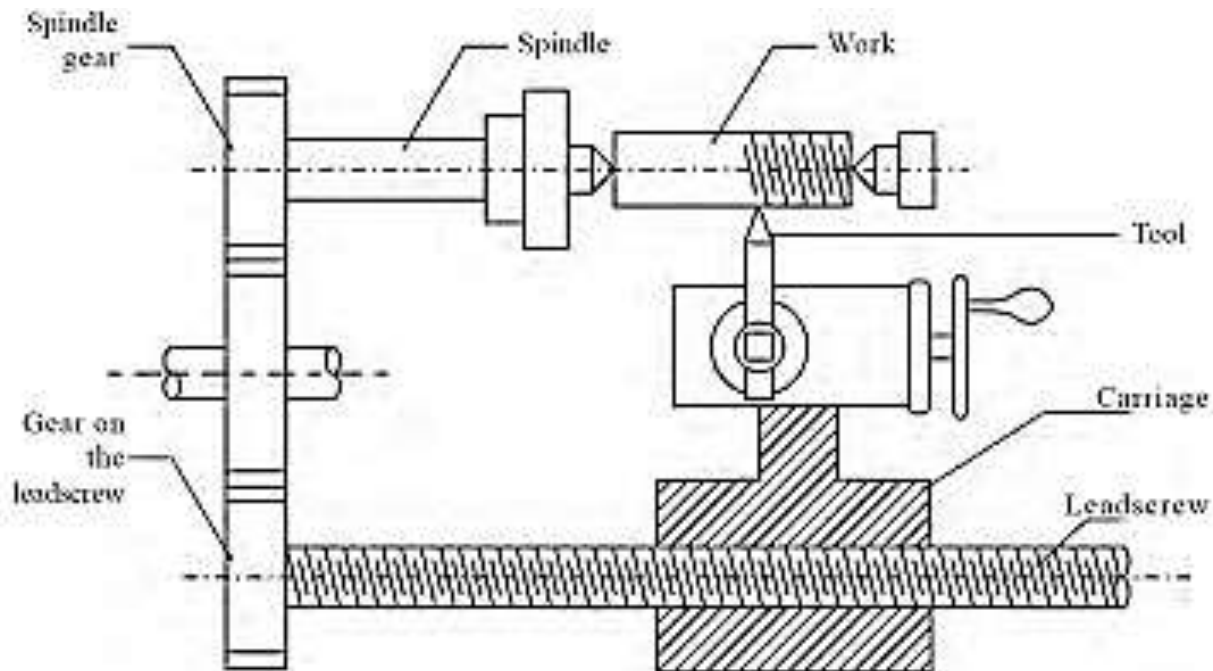
Screw threads may be manufactured by any one of the following methods :

- 1.Thread cutting on a lathe
- 2.Thread chasing
- 3.Die threading
- 4.Tapping
- 5.Thread milling
- 6.Thread rolling
- 7.Thread grinding
- 8.Thread casting
- 9.Thread whirling



# Thread Cutting on a Lathe :

- Using a single point form tool.
- Lead screw of the machine to control the form and lead of the thread respectively.
- Both internal and external threads can be cut.
- The full depth of the thread is produced by a number of successive passes each with a small depth of cut.



# Thread Cutting on a Lathe :

contd...

- The method is extremely slow and cannot be made automatic.
- The process of engaging and disengaging of the carriage half-nut using a chasing dial requires considerable skill and attention of the operator.
- Screw cutting with a single point tool is still an economical method for one piece or small quantity production.

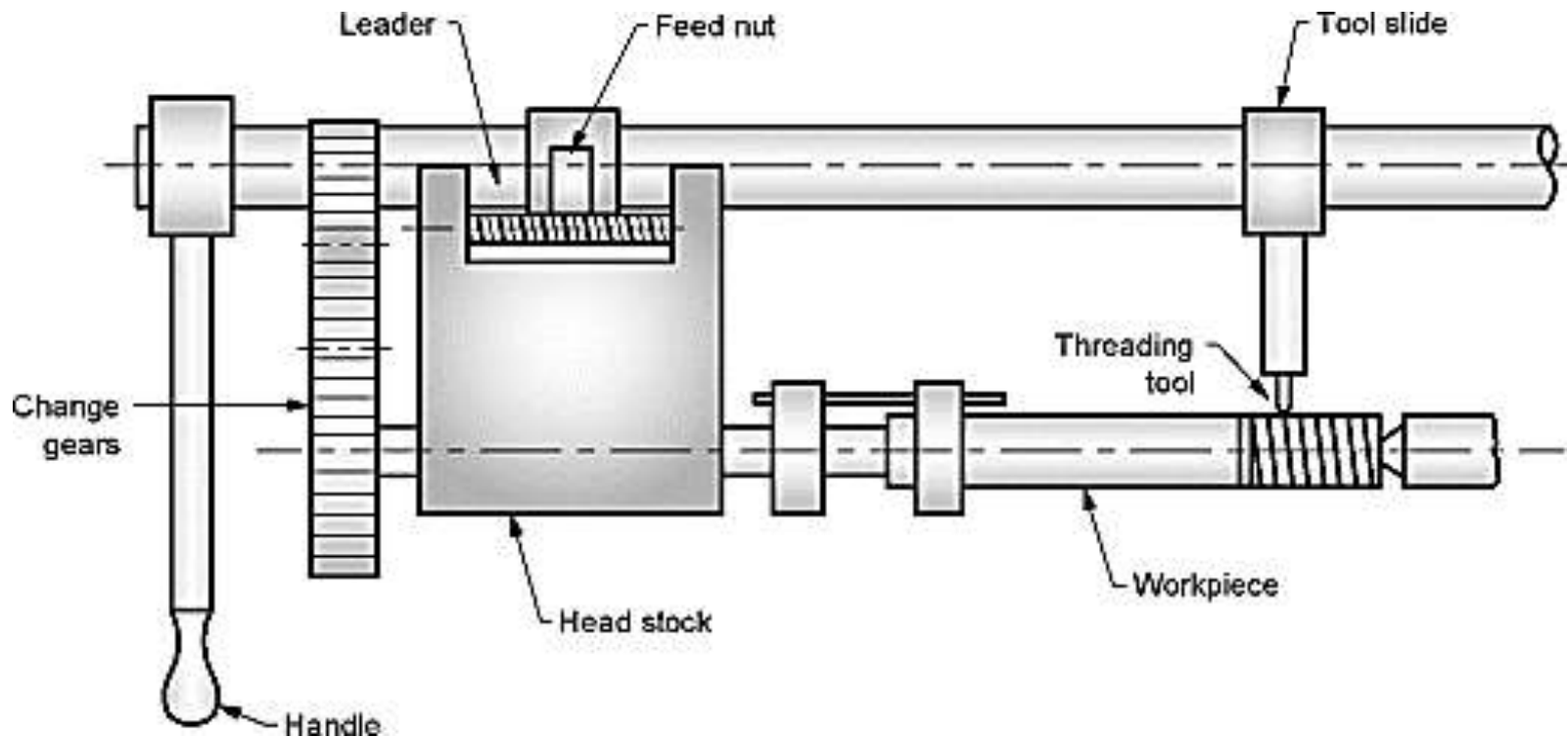
## Thread chasing:

- A chaser is a multi-point threading tool having the same form and pitch as that of the thread to be chased.
- The device may be in the form of an attachment used on the lathe or may be built into a special purpose machine.
- In this device power from the headstock of the machine is given to a short lead screw known as the leader by means of change gears.

# Thread chasing:

contd...

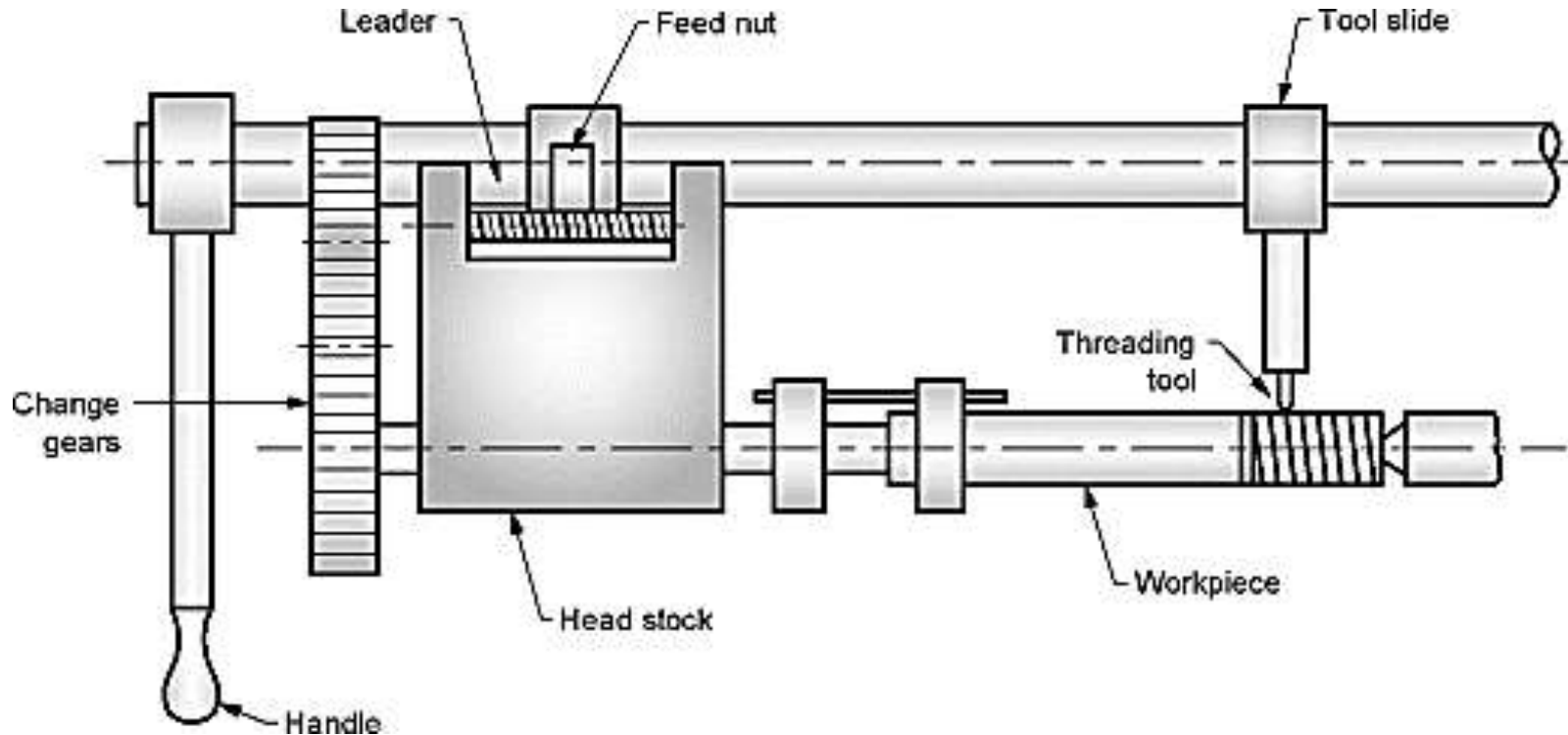
- Power from headstock is given to a short lead screw known as the leader by means of change gears.
- The feed nut and the tool slide are carried on a shaft which can be engaged or disengaged to the leader with the help of the handle shown.



# Thread chasing:

contd...

- The feed nut can be engaged to the leader at any position of the work rotation.
- The operation is carried out at about 50 percent of the speed for turning .
- Allows considerably higher cutting speeds to be used.



## Thread cutting dies:

contd...

- The dies used in die threading may be solid or self opening type. Solid dies are made of high speed steel and are mainly used for hand threading but can be used on turret and lathes with suitable holders.
- Some **adjustable dies** are available with provision for size compensation of wear on dies.
- **Solid dies** are made of carbon steel or H.S.S and are generally used for threading by hand.
- The main drawback of these dies is that after the thread has been completely cut, the die has to be withdrawn by reversing the spindle.

## Thread cutting dies:

contd...

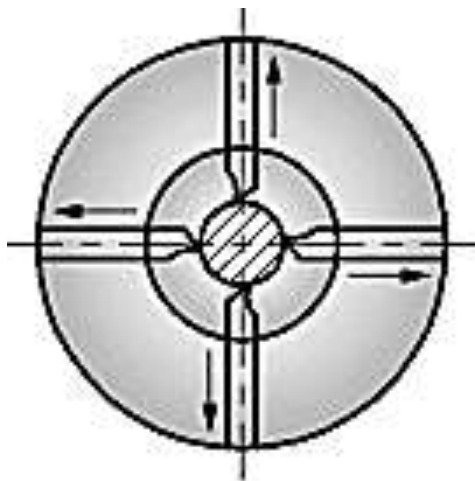
- The **self-opening dies** use H.S.S. chasers mounted in die heads.
- The die heads are provided with arrangement for opening and closing of the thread chasers within the die head.
- After the thread has been completed the chasers are withdrawn radially outwards in the body due to the action of a cam or scroll.
- This clears the chasers from the threads. The die head can be withdrawn without reversing the spindle.

# Thread cutting dies:

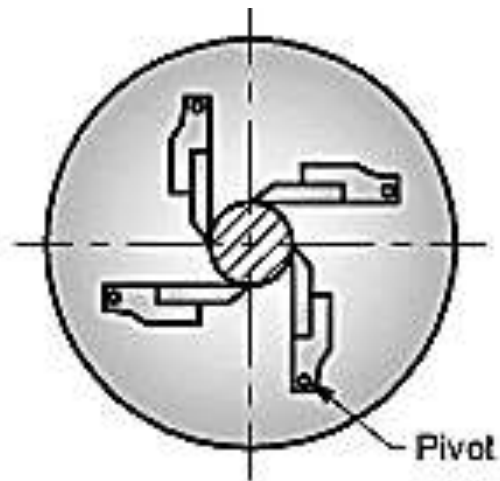
contd...

- Depending upon the type of chasers, **self opening die heads** can be classified into three main types :

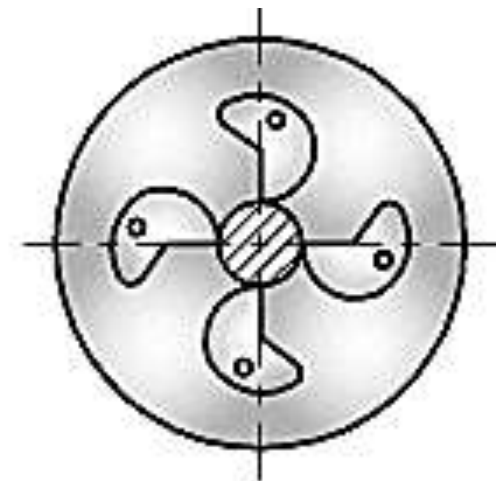
- (1) Radial
- (2) Tangential
- (3) Circular



(a) Radial



(b) Tangential



(c) Circular die



# Tapping:

- Tapping is a thread cutting process for producing internal threads.
- Like die threading tapping also uses multipoint cutting tools called taps and may be done manually or on machines.
- The use of tapping tools with machines essentially follows the same procedure as manual tapping.



# Tapping :

contd...

- Feed being automatic with the machine, the threads produced are more accurate and uniform.
- Machining rate can be considerably increased by providing the machine features like...
  - fast retraction of the tool,
  - continuous or automatic loading and unloading of parts and
  - use of multiple spindles.

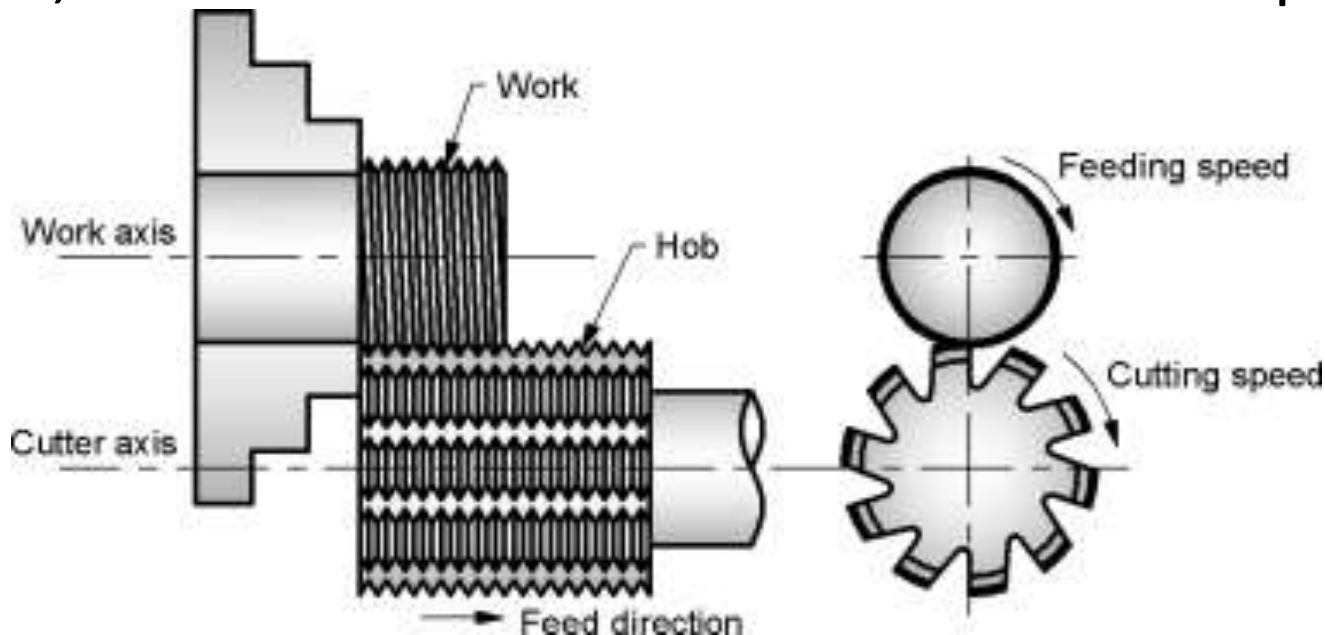
## Thread milling :

- The most common method of thread milling is with a multi-tooth cutter called **hob** on a thread milling machine.
- The hob is carried in a cutter head mounted on the carriage that slides between the head stock and the tail stock.
- The cutter and job axis lie in parallel planes with the cutter set at an angle equal to the lead angle of the thread.
- The cutter rotates at the milling speed while the job is revolved at a slow feeding speed.

# Thread milling :

contd...

- During operation the revolving cutter is first fed to the full depth into the work.
- Then fed lengthwise along the slowly revolving workpiece.
- So that by the time the thread being cut encircles the job diameter, each thread would have advanced one pitch.

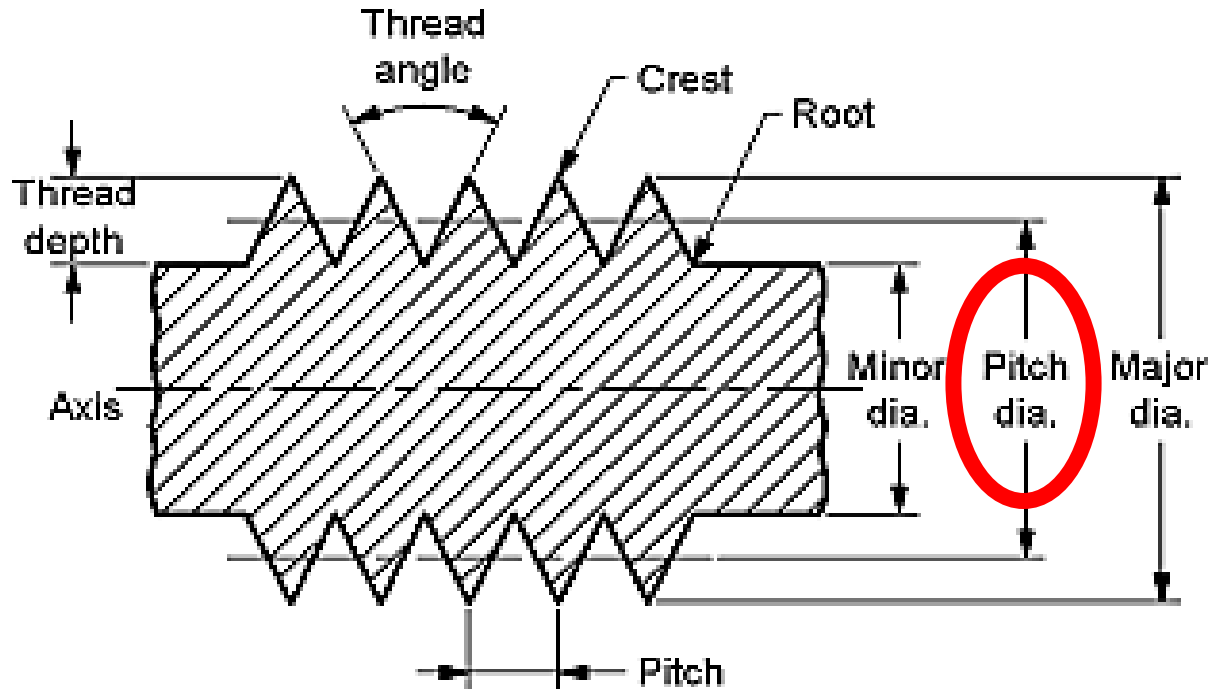


## Thread rolling:

- Produces external threads by a cold forging operation rather than a cutting operation.
- This is achieved by subjecting a thread blank to pressure between two hardened steel dies.
- The surfaces of the dies carry reverse form of the thread to be cut.
- Application of pressure causes plastic flow of the material.

# Thread rolling:

- The diameter of the blank is approximately equal to the pitch diameter of the required thread.

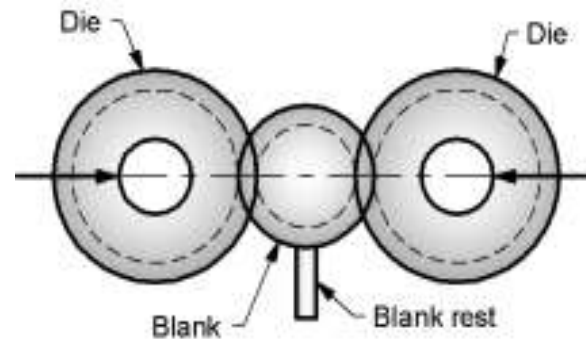
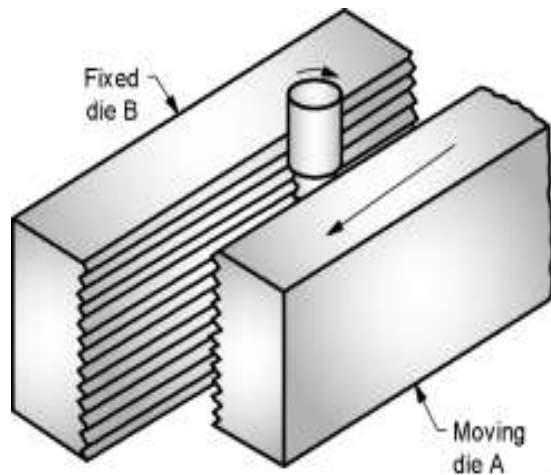


- The die thread penetrates to form the depression or roots of the thread while the displaced material forms the crests and flanks.

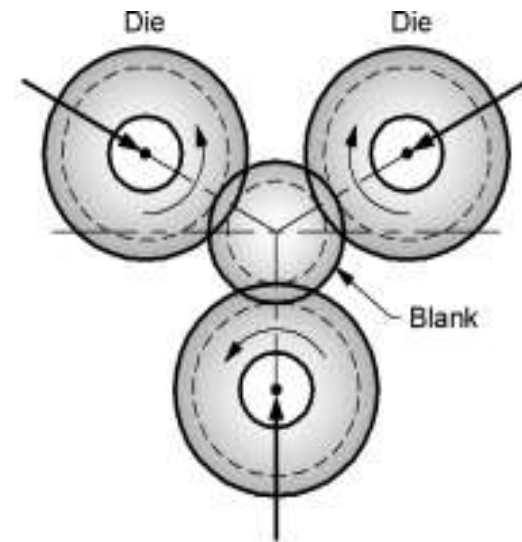
# Thread rolling:

contd...

- Dies may be in form of grooved blocks or threaded rolls.
- Thread rolling can be carried out on any material that can withstand the forging pressure.
- Two types of dies are in common use for thread rolling.
  - Flat dies
  - Cylindrical dies



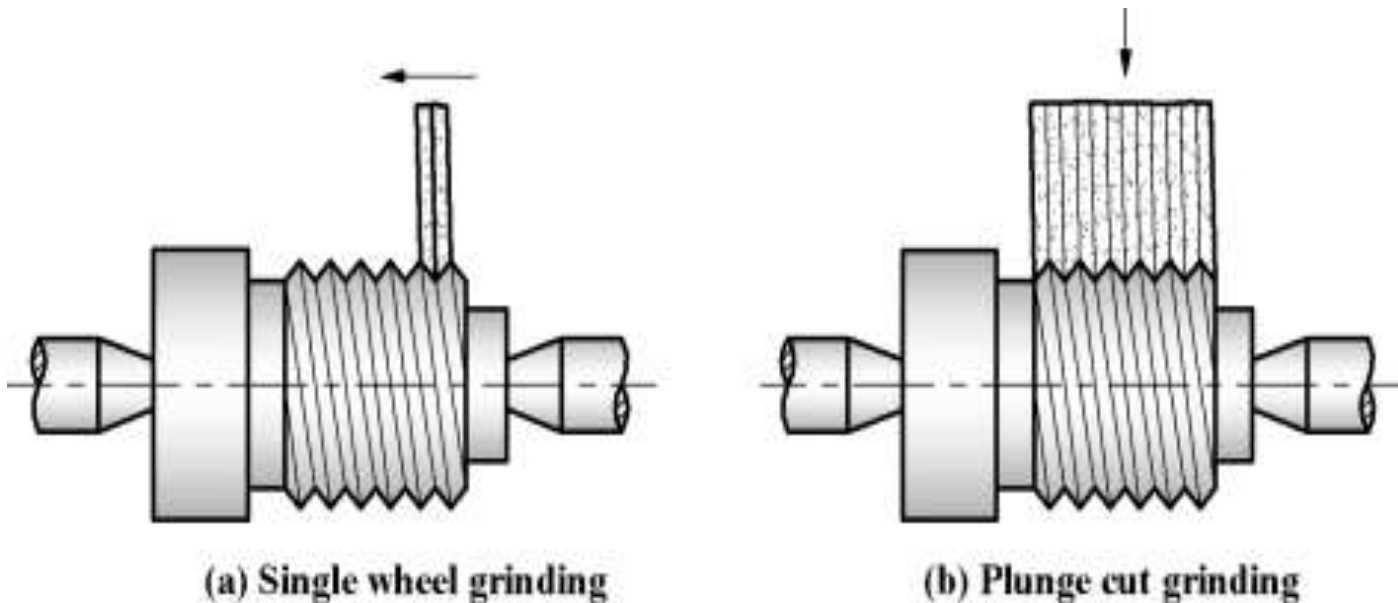
(a) Two die method



(b) Three die method

## Thread grinding :

- Thread grinding is used as a forming or finishing operation.
- Done on threads which are required to have a very high degree of finish and accuracy.
- Materials which are very hard or very soft and for threads which have been heat treated.



- A lot of cutting fluid must be used to get the best results.



## Thread casting:

- The accuracy and finish of threads produced by casting depends on the casting process used.
- Threads made by sand casting are rough and are not used much except in some vices and rough working machinery.
- Threads made by die casting and permanent mould casting are quite accurate and of high finish.
- These methods can be used to produce external and internal threads in complex jobs but the methods are suitable for low melting temperature metals.

## Thread whirling :

- The process can be carried out on special thread whirling machines or on standard engine lathes equipped with thread whirling attachment.
- The thread whirling equipment essentially consists of a tool holding ring which carries four carbide tipped tools, mounted at 90 degree to each other.
- The ring is set eccentric to the work axis and is run at speeds of 1000-3000 rpm by an independent motor.
- The carrier unit can be swivelled to set the tool path along the axis of the helix angle of the thread and is provided with a setting microscope for setting the tools.

# Thread whirling :



## Thread whirling :

contd...

- The whole unit is mounted on the carriage of the machine and is provided linear motion corresponding to the pitch of the screw being cut by gearing it to the machine lead screw.
- The work piece, mounted horizontally is provided a slow rotational motion of 3-30 rpm from the headstock through a reducer.
- Two of the whirling tools cut along the flanks of the thread, the third cuts at the root while the fourth one which has the full tooth form finishes the thread.