7/1/2017

1

Basic Element of Machining :

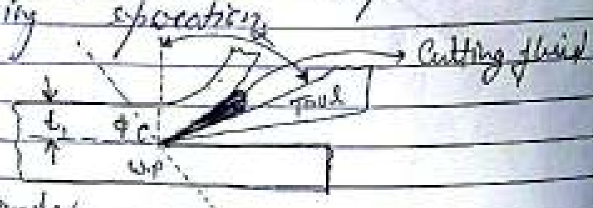
- work piece
- Tool
- Chips
- Cutting fluid

* For cutting action the relative motion b/w tool & work piece is necessary. This relative motion b/w tool & the w.p can be provided by either keeping the w.p stationary & moving the tool or by keeping tool stationary & moving the w.p or by moving both in relation to each other.

* Chemical & physical properties of w.p material have significant effect on the machining operation.

* Similarly, tool material & geometry are equally imp. for better machining.

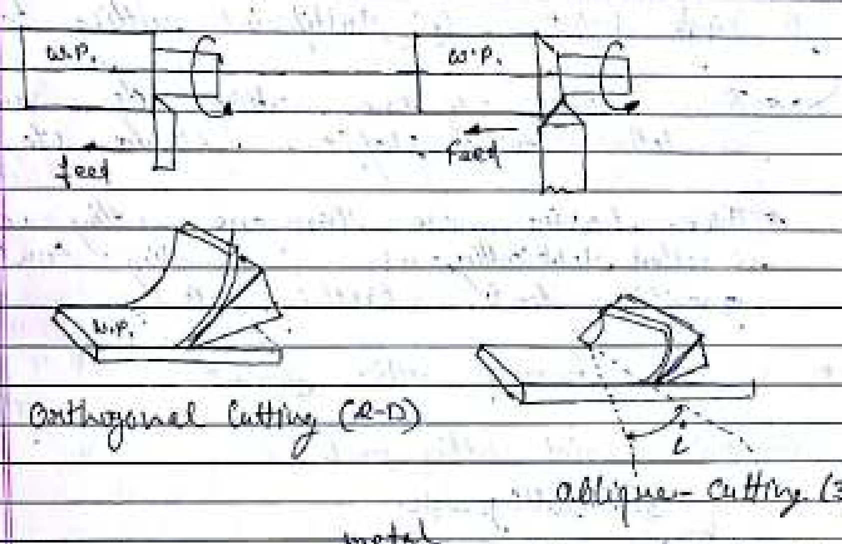
* Chemical composition and state of cutting fluid also provide considerable influence on the machining operation.



α – rake angle
φ → shear angle

2

Orthogonal & Oblique Cutting :



Orthogonal Cutting (2-D)

Oblique Cutting (3-D)

* The process of metal cutting is divided into following two main classes–

(1) Orthogonal, (2) Oblique cutting

(1) Basically in orthogonal cutting the cutting edge of the tool remains at right angle to the direction of the cutting velocity. This type of cutting is also known as 2-D cutting.

(2) In oblique cutting edge of the tool is inclined at an acute angle with the direction of the tool feed. This is also known as 3-D cutting.

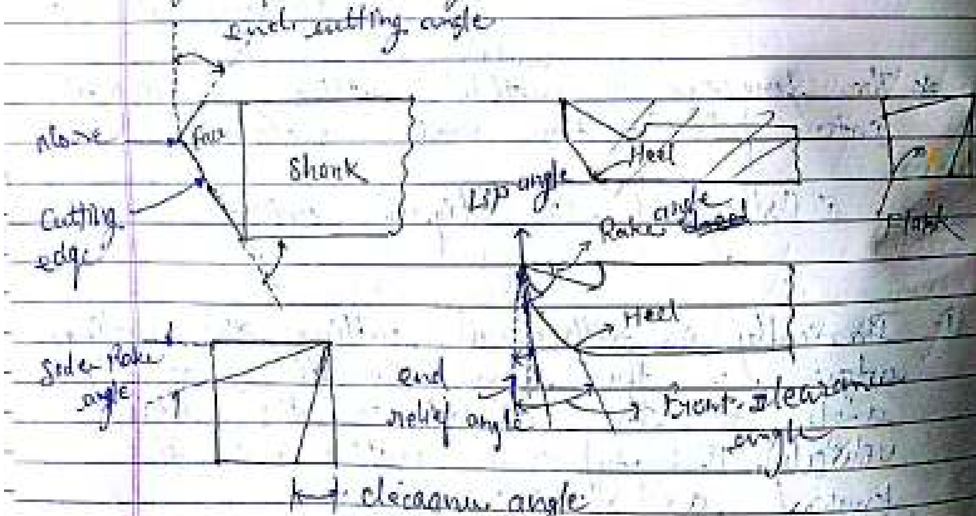
Classification of cutting tool

1. Single point, 2. Multipoint cutting tool

* These having only one cutting edge such as lathe tool, shapper, planner etc.
* These having more than one cutting edge is called Multicutting such as milling tool, grainding tool, broching etc.

Important part of cutting tool

1. Single point cutting tool :-



Stem/Shank :- It forms the main body of the solid tool and the part of the tool which is to hold by the tool holder.

* Face :- top surface of the tool b/w rack and the cutting point of the tool. In cutting action chips flow along the face.

* Cutting point :- it is the wedge shaped portion where face & flank of the tool meet. It is some time called as nose. and it is cutting part of the tool.

Flank :- Portion of the tool which faces the work piece is termed as flank.

Base :- It is actually bearing surface of the tool on which it is hang.

Heel :- It is the curved portion at the bottom of the tool where the base & flank meet.

Nose radius :- At the cutting process for the stress reduction nose like shape is provided. due to above this base strength of the cutting tipe is increases (0.4mm - 1.6mm radius of nose is provided). It is also increases the tool life.

Rake angle :- Angle b/w face of the tool & a plane parallel to its base. If this elindation is toward the sank then it is known as back rake angle or tope rake and when it is measure towards the side of the tool then it is called side rake.

It guide the chip flow so reduces the chip pressure on the face.

An increase in rake angle will reduce the strength of the cutting edge. Some time in cutting process zero rake & negative rake is also provided.

* Lip angle :- Angle b/w face and flank is known as lip angle. Larger the lip angle stronger will be cutting tip.

* Clearance Angle :- (end relief angle)
It is the angle formed by the front or side of surface of the tool which are adjacent and below the cutting edge when the tool is held in horizontal position. The purpose of clearance angle is the cutting of the w.p without rubbing against the surface of the job.

* Relief angle :-
It is angle formed b/w the flank of the tool and perpendicular line drawn from the cutting edge point to the base of the tool.

11/1/2017

Tool Material

* Properties required :-

① - Red or hot hardness :- It is a ability to withstand high temp. without its cutting edge. The red hardness of tool material can be increased by adding chromium, tungsten, molibdenum etc. All these makes carbide.

② - Toughness :- It should be high for impact loading.

③ - Wear resistance :- it is tool material should have ability to resist wear due to adhesion & abrasion.

④ - Low friction :-

⑤ - Low coeff. of thermal expansion :-
⑥ - Good thermal conductivity → (transfer heat)
⑦ - High specific heat (less increase in temp. during heat generation)

* Common Material for tool

(1) * Carbon steel :- (medium Carbon & low carbon steel)

(2) * H.S.S :- it is used for making cutting tool which is used for cutting at high speed. H.S.S. are generally of two type
1) M-series (Molibdenum type 10% around)
2) T-series (Tungsten type 12-18% around)

Scanned by CamScanner

Tungsten → 18%
Chromium → 4%
Vanadium → 1%

18-4-1 is the extensively used H.S.S. for cutting tool in which Tungsten is 18%, Chromium 4% and Vanadium is 1%.

M series generally have less high abrasion resistance than T-series.

Hardness of H.S.S. falls rapidly beyond 650°C and thus they are limited to cutting speed of 30-50 m/min. Cheap & destructive.

(3) * Stellite :- It is a non-ferrous alloy containing cobalt (40-55%), chromium (30-35%), carbon (0-5%) along with few tantalum, molybdenum & boron. These are produced by casting & specially used for form tool.

Properties are intermediate b/w H.S.S & carbide but they are not as tough as H.S.S. and it is sensitive impact load. It retain hardness upto 900°C & used for cutting at speed upto 50m/min.

* Cemented Carbide (Cermets) :-

(4) * Cemented carbide :- These are made by powder metallurgy in which mixture of tungsten, titanium, tantalum are mixed with carbon to form carbide.

The carbide in powder form are then mixed with cobalt which act as binder. Then this compacted mixture is heated over 1500°C and the result of this they are sintered into desired shape & form of tips.

These carbide tips are brazed or mechanically fastened to be sank which is made up of medium carbon steel this provide an excellent combination of extra hard cutting edge with a tough sank of tool.

It retain hardness up to one thousand degree centigrade & it can cut at the speed of 60 m/min. to 300 m/min.

(5) * Ceramic or Cemented Oxide :-

It's composition consist of Al_2O_3 added with silicon carbide, magnesium oxide, chromium oxide, nickel oxide, titanium carbide etc.

Ceramic tool cannot machine because at the high temp. the compound present it have strong affinity toward tool material as result of which chemical reaction may takes place

These tools are not brased but clamped.

It retains hardness upto the temp. 400°C & speed of cutting is around (200 – 600) m/min.

20/1/2017

(6)

* **Diamond :-** It is hardest non-material & it has good thermal conductivity, low friction but costly.

It is not used for machine steel because of its cost as well as diamond undergoes allotropic transformation into graphite on interaction with iron at 720°C temp.

In industry artificial diamonds are used.

(7)

* **Cubic Boron Nitrite :-** – Boron has hexagonal structure but when it is heated under const. pressure it converts into cubic which is very hard structure.

– It is not a natural material and it is produced in lab by bonding a layer of poly-crystaline cubic boron nitrite.

– It is used for machining stainless steel at high speed (600–900 m/min).

– Some times it is also used as abrasive particle for grinding wheel for grinding very hard material.

* ~~Sialon~~ :-

(8)

* **SIALON :-** Stands for silicon nitrite based material with aluminium & oxygen

These tool have got toughness & hardness compare to conventional ceramic.

Due to chemical affinity of iron it is not used for machining steel. It produces excellent surface finished. but it is also costly.

* UCON :- It is preclical by rolling and used for machining at very speed & feed. It consist of ~~cobalt~~ columbium – 50%, Ti – 30%, Tu → 20%.

Imp

Cutting Speed, Feed, Depth of Cut

* Cutting Speed :- It is defined as the rate at which its cutting edge of the tool passes over the surface of w/p in unit time. Generally its expressed by meter/min.

It's very imp. as it effects the tool life & efficiency of maching.

If it is to high the tool get over heated and its cutting edge may fails & ~~this case~~ would be need of re-grinding.

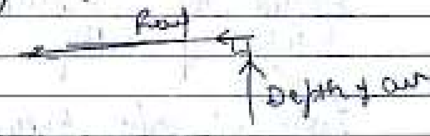
If it is too low it will take to much time in machining which results in lower of productivity & will increase the cost.

* Feed :

Feeding of cutting tool can be defined as the movement of cutting tool per cycle relative to work-piece in a direction which is usually perpendicular to the cutting speed direction.

It is expressed in mm/revolution or mm/stroke.

* Feed rate is decided on the following factors–
- Smoothness of finishing required
- Power available
- Type of cut
- Tool life



* Depth of Cut :- It is the thickness of layer of metal removed in one cut or pass measured in perpendicular direction to the machine surface.

Depth of cutt is always perpendicular to direction of feed motion.

* Machineability *

It is defined as the ease with which a given material can be cut & permitting the removal of material with satisfactory finished at lower cost.

⇒ Good machineability is associated with:–
→ higher cutting speed
→ lower power consumption
→ good surface finish

for exple:- excellent machineability - mg, Al, zinc alloys

wt- machineability - Stellit, white cast iron

Lathe

A lathe can be defined as machine tool which holds the revolving w/p in a strong head and a stationary cutting is feed against the revolving w/p to perform various type of cutting operation.

Lathe is also known as mother of machine tool. And engine lathe is most basic and simplest form of lathe.

* Types of Lathe :-

Lathe are manufacture in variety of types & sizes. The different types of lathe are -

① Speed lathe, ② Bench lathe, ③ Engine lathe ④ Tool room lathe, ⑤ Turrent and Capstan lathe ⑥ Special purpose lathe, ⑦ Automatic lathe.

A BE SSTT

A BESSTT

Types of Lathe

- Speed lathe :- It is the simplest of all types of lathe. It is used as wood working lathe, metal spinning and polishing lathe.

Speed lathes normally do not posses gear box, carrage and lead screw.

Tool is feed manually. Speed lathe is power driven and spindal speeds upto about 4000 rpm commonly.

- Bench lathe :- is a small engine lathe which can be mounted on a bench. Bench lathe are used for small & light job which require precision.

In bench lathe mostly all the operation can be performed.

- Engine lathe:- it is basic turning machine. Its main components are - the bed, head stoke, tail stock, carrage and quick change gear box.

Engine lath differs from a speed lathe in terms of additional features of controlling the spindle speed and supporting the cutting tool in both, cross & longitudinal direction.

An engine lathe can be driven by an independent electric motor or a no. of lathe may be driven by an over-head shaft with the help of belts.

Work speed may be changed with the help of cone pully or through gear shifting. It is most widely used lathe and some time it also reffered to center-lathe.

• Tool Room Lathe :- A tool room lathe is a precission engine lathe equiped with additional attachments needed for the tool & die making operation.

A tool room lathe has geared head stocks with a considerable range of spindle speed from very low to as high as 2500 rpm.

A tool room lathe is carefully tested for accuracy and used for making highly accurate, low production work of small parts such as its test gauge.

A tool room lathe is more expensive than comparable sizes of the engine lathe.

Turrent

• Direct and Capstan lathe •

⇒ It is used for mass production work.

⇒ These machine are actually of semi-automatic type & very wide range of operation can be performed on them.

⇒ In operating of these machines very little skill is required i.e. skill required is only in setting of tools in turret or capston head.

⇒ The no. of speed is high. They carry special mechanisms for indexing of their tool head.

⇒ Front and rear tool post are available tool changing time is less. It has turret head instead tail stock.

⇒ Six different tool can be fitted in turret lathe.

• Automatic lathe/ Special purpose •

⇒ Working and loading of job is fully automatic. Used for quality & quantity work.

⇒ They fall into the category of heavy duty, high-speed lathe mainly employed in mass production.

• Special purpose lathe •

It is used for manufacture those job which cannot conviniently produced on normal lathe.

gth
→ Carry out certain specified operation only but more efficiently than a standard lathe.

→ Some Special purpose lathe are -

⇒ Gape lathe, Crank shaft lathe, Duplicating lathe, tracer lathe, fashing lathe.

* Gape or Extension type of lathe :-

It is very simillar to tool room lathe except that the gape lathe can be adjusted to machine larger diameter w/p.
The operator can increase the swing by moving the bed a distance from head stock which is usually one or two feet.

By sliding the bed away from the head stock the gape lathe can be used to turn very large workpiece b/w centers.

* Dublicating lathe :- It carries a special tracer attachment connected to the carriage which moves along a cam template and guide the carriage.
It used for mass production of identical parts where a previously machined part works as template.

* Fashing lathe :-
In this lathe carriage is driven by a separate motor independent of the main spindle. It carries not tail stock. It is used to machine end faces fashion of bulky cylindrical job.

* Crank Shaft lath :-

It carries all attatchment like taper turning and threading etc. In addition no. of rest to support the shaft.
It is used for turning long part such as turbine, engine shaft, crank shaft etc.

Basic Parts of lathe

- Bed
- Head stock
- Tail stock
- Carriage
- Apron
- Cross slide
- Compound rest
- Tool post

* Bed :-
- It is usually a casting of iron (cast iron).
- All the parts of lathe such as head stock,

tail stock etc. are mounted on the bed.

- Cast iron bed not only having very good vibration absorbing capacity but also facilitating an easy sliding action.
- Lathe bed should be sufficient weight and be of suitable material so that vibration generated during operation are damped out.
- Lathe bed are generally aged.

30/1/19

* Head stock :-

It is a box like casting mounted permanently on the left hand side of the bed.

Head stock support the spindle & contains a gear box by which work piece may be rotated at various speed. Spindle is tapered at the nose to have live centre.

Spindle is hollow to accept the bar stock and is build into head stock with spindle nose projecting from the housing of the head stock.

Spindle nose is threaded so that a face plate or chuck can be mounted on it to hold the w/p.

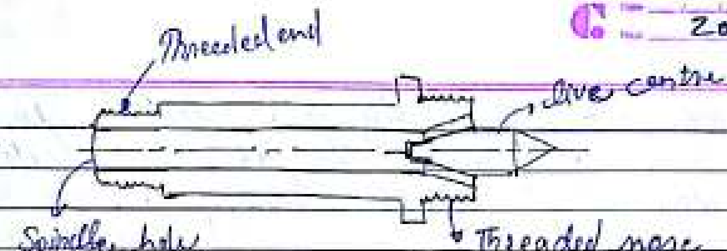


fig:- A threaded spindle nose with a live centre.

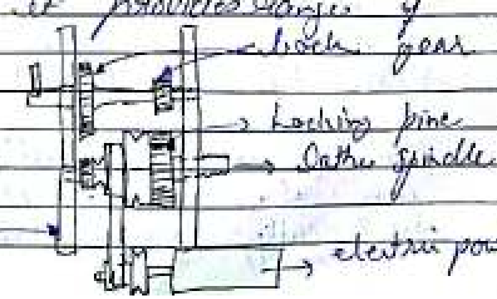
⇒ For cutting different material with different tool range of speed is required this range can be provided generally by two different types of head stock —

1) belt driven head stock
2) All geared head stock.

① * Belt driven head stock :-
A belt driven head stock comprises/consist step cone pully and back gear arrangement.

Cone pully in head stock give three or four possible spindle speed.

Back gear are used for reduction in spindle speed so it provides range of speed.



As shown in fig. a locking pin can be used to ingage or disingage cone pully with back gear.

② All geared Head Stock :-

Modern & specially larger lathe is corporates all gear head stock where spindle speed readily change with external handle & lever.

Here, the gear wheels are mounted on splines.

In all geared head stock lubrication is very important and it is done by splash.

All geared head stocks can be observed with small and compact in design, easy change in speed with high efficiency.

③ Tail Stock ⊙

Tail stock is located at right hand end of the bed. It is a non rotating part which can move left & right side of the lath bed to adjust the length of the work piece.

It is used to support long job, it can also be offset about 25mm for cutting small sm angle tappered & securily clamped to any position on the bed.

Tail stock is also known as loose centre. It consist of cast iron body in which a barrel is located. The barrel is hollow and tappered part with dead centre.

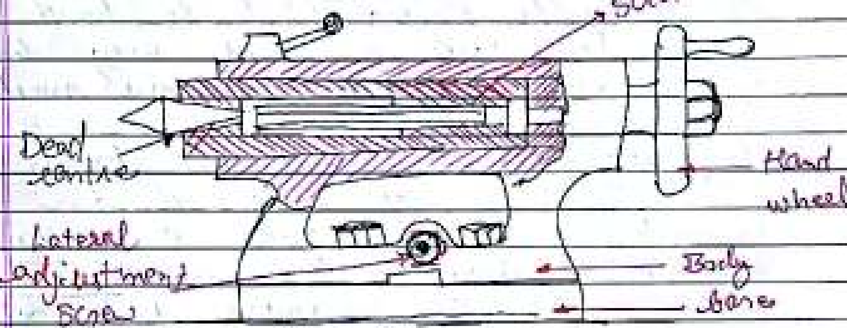


Fig:- Tail stock

31/1/2017 ⊙ (D) lathe Carrige ⊙

The lathe carriage serves the purpose of supporting, guiding and feeding the tool post against the job during the operation on lathe.

The carriage consist of the following main parts —

(1) Saddle, (2) Cross Slide, (3) Compound rest (4) tool post, (5) Aprone.

* Saddle :- It is the part of carriage which slides along the lathe bed

and support the cross slide.

* Cross Slide :- It is mounted on the type of the saddle and always moves along the perpendicular direction to the axis of lathe or main spindle.

It can either operated by hand or cross feed scale or it may be given power feed by aparone mechanism.

* Compound rest :- It is also known as tool rest and it is mounted on cross slide. It carries a graduated circular disc called swivel plate which allows the movement of the tool along the angular direction not parallel to lathe axis.
It support the tool post. Compound rest doesn't have any power feed.

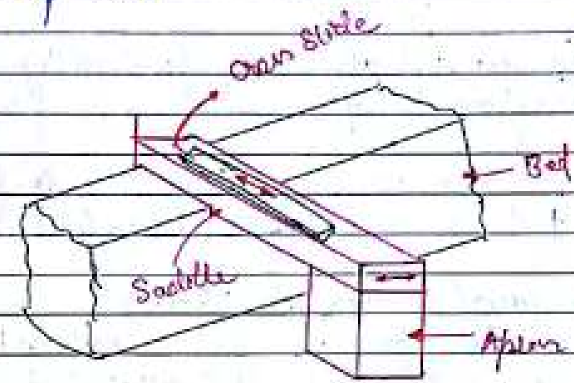
* Tool post :-

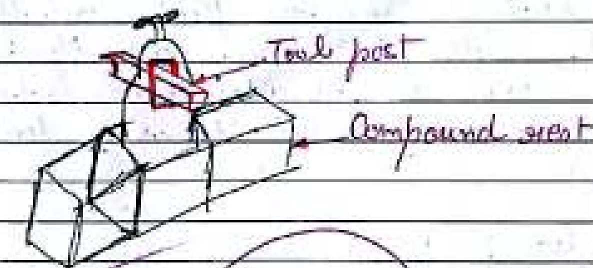
It is the type most part of the carriage. It use to hold tool or tool holder. It is mounted on compound slide. It may be of american type, english type or turret tool post.

* Aparone :-
It is the hanging part in front of carriage it serve as housing for

It no. of gear train through which power feed can be given to carriage & cross slide.

It also carries the clutch mechanism & split half nut





Work Holding devices

* Chuck:–
They provide very efficient & true device for holding the job & work in lathe during the operation.

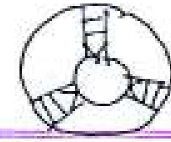
It save considerable time for setting a job as compare to face plate.

There are so many varities in chuck but few of them are given below

① Three-jaw (Universal Chuck)
It is also known as scroll chuck or self centering chuck. It consist of a cylindrical body having three jaws fixed radially at its front. In three jaw chuck all the jaw move simentaintically when chuck wrinch is use to tight or to loose the jaws.

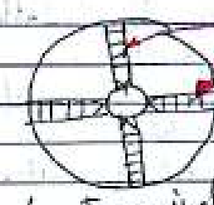
Advantages:–
- Job can be held easily & it is less time consuming
- Wide range of cylindrical & hexagonal job can be held.
- Extand & internal jaws are available.

Limitations:–
- Only regular round component can be held


3-Jaw self centring chuck

- Accuracy decreases due to weare after some time.
- It provide less gripping surface.

② Four jaw chuck:–



4-Jaw independent chuck

It has not only one more extra surface to gripe, but also all the jaws can be independently move with respect to each other.
It can securily gripe rectangular and irregural shapes of the w/p.

Advantages:–
- Wide range of rectangular & irregural job can be held.
- Holes can be drill concentrically and ecentrically as well.
- High gripping power so heavy cut can be performed.
- Even if the chucks worn out there is no loss of accuracy.

Limitation:–
- It setting up time is more.
- As it lead to high gripping force work can be easily damaged.
- Chuck is heavy to handle on lathe

Face plate :-

A metal plate with a flat face that is mounted on the lathe spindle to hold irregular shaped work.

A holding accessory for a wood or metal turning lathe. The workpiece is clamped to the faceplate typically using t-nuts in slots in the faceplate.

Lathe Dog

Also known as lathe dog or dog. An 'L'-shaped adapter, usually made of cast iron, with a hole for the workpiece and locking to secure the work in place. Used to clamp a w/p and apply rotational force to it while the w/p is mounted b/w centers along with a faceplate. The dog engages with a hole in the faceplate to apply the force to the workpiece. Used in place of a chuck especially in pre-1940's work and when tapers are cut by offsetting the tailstock.

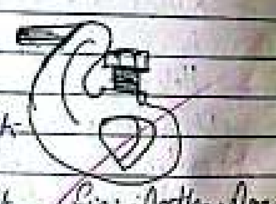


Fig: Lathe Dog

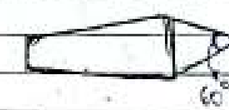
Collets :-

A collet is a subtype of chuck that forms a collar around an object to be held & exerts a strong clamping force on the object when it is tightened, usually by means of a tapered outer collar. It may be used to hold a workpiece or a tool.

The following traits making it highly useful for repetitive work –

- Fast chucking, self centering, strong clamping, resistance against being jarred loose (untightened), precise centering.

Centres (live and dead centre)



Live centre   Dead centre

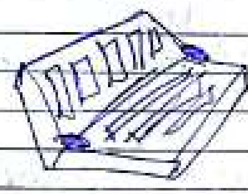
A precision ground tapered cylinder with a 60° pointed tip and a Morse taper shaft. Held in the lathe tailstock to support the end of a long w/p. May also used in the headstock spindle to support work b/w centres at both ends. Also the process of positioning a w/p accurately in the line with a drill or mill. A live center is a center with integral bearing to reduce friction; a dead center has no bearing, so tip must be kept lubricated to keep the center and w/p from overheating due to friction.

Mandrel :-

A mandrel is a round object against which material can be forged or shaped or a tool component such as a chuck that grips or clamps material to be machined in a lathe, or any other part which is to be spun or rotated.

Mandrel are also used in industrial composite fabrication such as in filament winding. During the manufacturing process, resin-impregnated filaments are wound around to a mandrel to create a composite structure or parts

Angle plate :-



An angle plate is a work holding device used as a fixture in metalworking

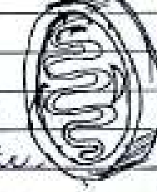
The angle plate plate is made from high quality material (generally spheroidal cast iron) that has been stabilized to prevent further movement or distortion

Adjustable angle plates are also available for w/p that need to be enclined usually towards a milling cutter

Steady Rest and Follower Rest :

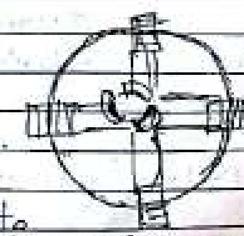
Steady rest and follower rest were developed to remedy the lathe turning deflection problem. Steady rests and followers rest hold a long w/p during turning. steady rest are mounted to the lathe bed and do not move with the lathe. They ensure concentricity but limit the length of the supporting cut. Followers rests are so named because they attached to the saddle and move along with or follow the lathe.

Magnetic chuck :



Magnetic chuck is a another type of holding device, which work on the principle of electromagnetic induction. Magnetic chuck is not suitable for heavy work. Easy to use and hold the device.

Combination Chuck :



Combination chuck is the combination of three jaw, four jaw and with collets. It can hold any job of any form of shape. Its uses is less due to its robust construction skilled worker is required.

Numerical Control (NC) M/c.

NC lathe machine, one or more of the following function may be automatic.

use magnetic tape on which component instruction

Component of NC lathe M/c system.

Advantage of NC lathe M/c -

1. Cycle time reduction
2. Complex M/c operation.
3. High degree of accuracy
4. less inspection required
5. Reduction of scrap & wastage
6. Increasing productivity.
7. lower tooling cost.
8. Reduction of human error.
9. Greater operation safety.

Limitation of NC lathe M/c

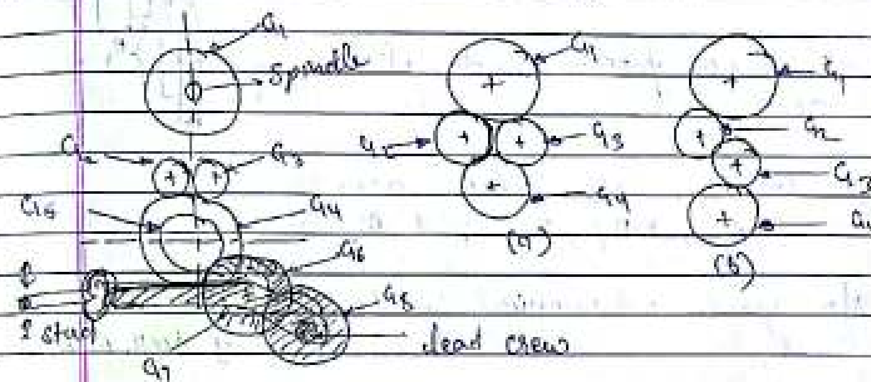
- high investment cost, high maintenance effort, need for skilled programmers, high utilization required.

* Introduction to CNC lathe M/c. (Computer Numerical Control)

we can stored the diff. program and use it any time repeatedly.

* D.N.C (Direct Numerical control)

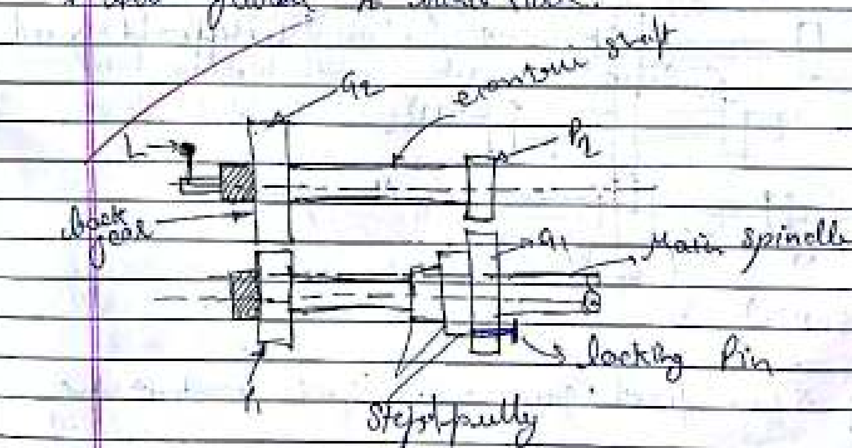
① Feed Mechanism & Change Gears ②



G2 | G3 can be shifted it position

② Driving Mechanism · ③

* Cone pully & back Gear
* All geared & head stock.



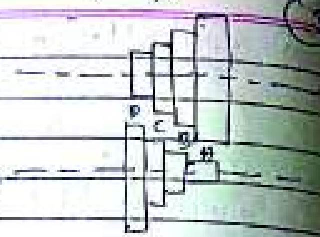
* Speed ratio:-

* disengaged position.

Spindle speed = Countershaft speed × $\frac{\text{Dia of counter shaft}}{\text{Dia of stepped cone}}$

(33)

* N_A, N_B, N_C & N_D



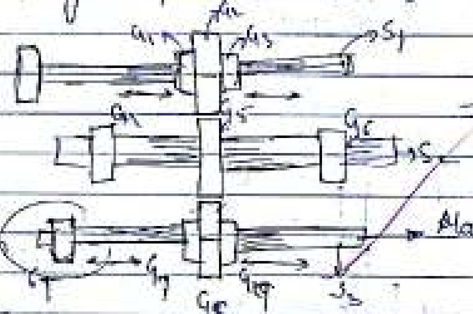
⇒ Engaged position with back gears.

* let the new speeds are N_{A_1}, N_{B_1}, N_{C_1}, & N_{D_1}

New speed = Previous speed × $\left(\frac{\text{No. of teeth in } G}{\text{No. of teeth in } G_1}\right)$ × $\frac{\text{No. of teeth in } G_2}{\text{No. of teeth in } G_1}$

New speed = Previous speed × K

* All geared head stock :-



9-different speed

If S is fixed speed and C is constant we then,

2nd speed = S.C
3rd speed = SC^2

n^{th} speed = Sc^{n-1}

Now, if n is total no. of speed and 'N' is maximum speed.

Then —

$$N = Sc^{n-1}$$

$$\Rightarrow c = \left(\frac{N}{S}\right)^{\frac{1}{n-1}}$$

a) $N_1 = \frac{G_1}{G_4} \times \frac{G_4}{G_7}$, $N_2 = \frac{G_1}{G_5} \times \frac{G_4}{G_7}$

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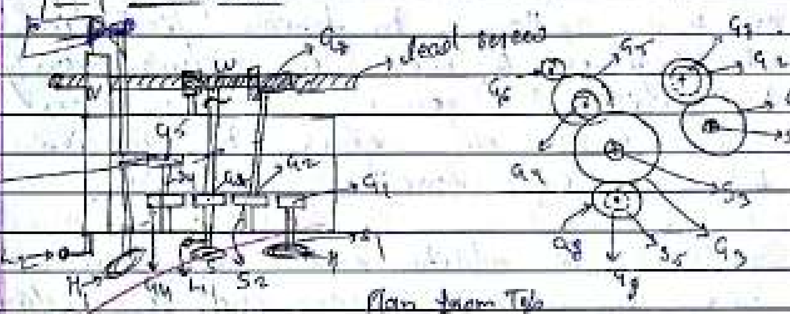
* Apron Mechanism :-



H is hand wheel for providing longitudinal hand feed to carriage, similarly H_1 is the hand wheel to providing hand feed to cross slide.

Lever L_1 is for engaging, increasing and disengaging the power feed.

Star wheel S is operated when power feed is to be engaged.

Lever L_2 operate to close or open the split half nut N inside the apron there are five spindles S_1, S_2, S_3, S_4 & S_5 as named in figure.

Spindle S_2 carries a gear G_7 at its rear end which mesh with rack provided at lathe front

Spindle S_3 carries gear G_3 which is operated by lever L_1. This lever has three position one, two, & three. In position first i.e. lower it engages G_3 with G_4 mounted on spindle. In position 2 gear G_3 is free does not mesh with any gears. In position 3, top gear G_3 meshes with G_2.

Spindle S_4 in addition to the G_4 carries another gear G_5 at its rear end. It is always in mesh with gear G_6 which is mounted on the screw rod of cross slide.

Spindle S_5 is just below the spindle S_3 & it carries of gear G_8 & G_9. G_8 is in mesh with G_3 & G_9 is in mesh with worm. However, gear G_9 is not rigidly fixed with to S_5. A clutch with which is provided to tight or to loose this gear on spindle S_5

The operation when hand feed is required to be given whether to carriage or to the cross slide whether the lever L_1 is kept kept at lower position.

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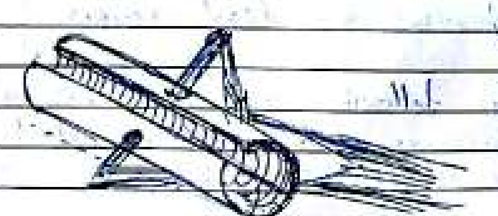
when power feed is be given to the carriage lever L_1 is kept in such position (upper) so that G_3 meshes with G_8 & G_2 simultaneously

To give the power feed to the cross slide the lever L_1 is kept in such position so that gear G_3 mesh with G_4.

* Working Mechanism of Split half nut *

A split nut is a nut that is split lengthwise into two pieces so that its internal thread may be opened and closed over the external thread of a bolt or leadscrew. This allows the nut, when open, to move along the screw without the screw turning (or, vice-versa, to allow the screw to pass through the nut without turning). Then when nut is closed, it resumes the normal movement of a nut on a screw. A split nut assembly is often used in positioning system, for example in the leadscrew of a lathe. The two halves of the nut have chamfered ends (60° to axis), which helps the thread to find engagement during the closing action. Split nuts work best with trapezoidal thread.



Internal threading.

Thread Cutting Mechanism

Thread cutting is the operation to producing a helical groove of specific shape like V or square on cylindrical surface.

Thread can be cut on cylindrical surface by forming or machining process. Thread cutting by machining is done by using lathe. On lathe machine thread of any pitch, shape and size can cut.

Thread cutting on lathe is done by thread cutting tool (single pt). For producing thread of pitch 'p mm' the tool must travel a distance equal to 'p mm' as work piece make one complete revolution.

The desired relative rotary & linear motion b/w the w/p & tool is achieved by locking or engaging the carriage with the lead screw through a screw nut mechanism & fixing a gear ratio b/w head stock spindle and lead screw. This is done by using change gear mechanism or gear box b/w spindle & lead screw.

The following relationship is used to determine the gear ratio required to generate threads of different pitch.

gear ratio = $\frac{\text{Pitch of Screw to be cut}}{\text{pitch of lead screw}}$

= $\frac{\text{lead of screw to be cut}}{\text{lead of lead screw thread}}$

= $\frac{\text{No. of teeth of driver (start gear)}}{\text{No. of teeth of driven (lead screw gear)}}$

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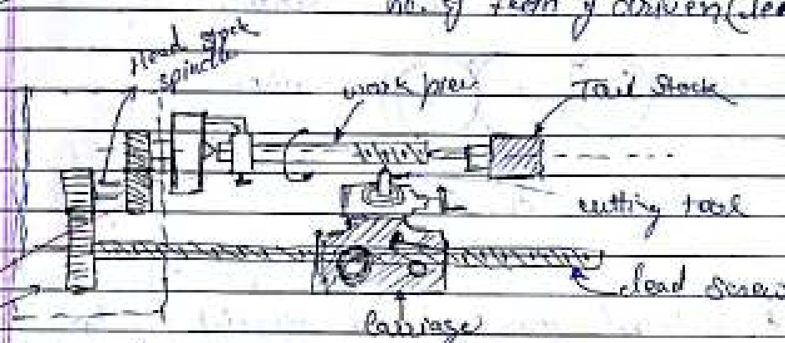


All the lathe m/c are provided with a set of change gear usually having 20 to 120 with variation of five teeth in addition a gear of 127 teeth is all provided which is known as translating gear used in metric threads.

After determination of above gearing ratio the next step to follow is to multiply the numerator & denominator of fraction by available teeth no. to find out the no. of teeth of the change gears.

There are two types of gears train are employed in cutting thread.

(1) Simple gear train (2) Compound gear train

Simple gear train consist of driver gear (mounted on stud shaft) & driven gear mounted lead screw and one or more intermediate gears. Intermediate gear have no effect on gear ratio.

A compound gear train consist of two stud set fitted instead of one. Such gear train is employed when desired gear ratio is such that it is not possible to arrange by simple gear train out of the given set of change gears.

Ques→ Calculat the change gear to cut RH thread of 2mm pitch on a lathe having lead screw of 6 mm pitch.

Solution: Gear ratio $= \frac{2}{6} = 1/3 = 1:3$

Change gear $= \frac{1}{3} \times \frac{20}{20} = \frac{20}{60}$ → Drive teeth / → Driven teeth

Ques→ Calculate the change wheel to cut thread of 1mm pitch on a lathe having lead screw of 8mm pitch.

Solution: $G.R = \frac{1}{8}$

Change gear $= \frac{1}{8} \times \frac{20}{20} = \frac{20}{160 > 120}$ (not permissible)

$= \frac{1}{2} \times \frac{1}{4} \Rightarrow \frac{30}{60} \times \frac{20}{80}$

compounding system

20/2/2017

* Cutting Metric Thread on English Standard Lead screw or vise-versa *

Many times it may be required to cut metric thread on lathe having british standard lead screw. in the case having its pitch in inches. In such case the following relation will help-

$\frac{Driver}{Driven} = \frac{5}{127} \times \frac{\text{lead of screw to cut}}{\text{(lead of thread on lead screw in inches)}}$

In case of reverse requirement that is when threads of british standard pitches are to be cut on lathe having lead screw in metric pitch.

$\frac{Driver}{Driven} = \frac{127}{5} \times \frac{\text{lead of screw to be cut in inches}}{\text{lead of threads on lead screw in mm}}$

Ques. Calculate the change gear for cutting a right hand single start thread of 0.5 inche pitch on lathe having lead screw of 8 mm lead.

Solution:
$$\frac{Driver}{Driven} = \frac{127}{5} \times \frac{0.5}{8} = \frac{127}{5} \times \frac{1/4}{8}$$
$$= \frac{127}{5} \times \frac{1}{32}$$
$$= \frac{127}{5} \times \frac{1}{(4\times4)\times2}$$
$$= \frac{127}{80} \times \left(\frac{1}{2} \times \frac{20}{20}\right)$$
$$= \frac{127}{80} \times \frac{20}{40}$$

© Operations on lathe M/C ©

All the operation can be performed on lathe can divide into two groups

→ **Standard or common operation**

They include plane & step turning, facing, taper turning, drilling, reaming, boring, knurling, threading, eccentric turning etc.

→ **Special or rare operation.**

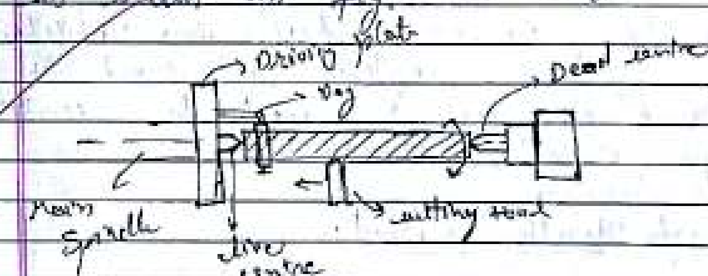
They include grinding, milling, copying, slab duplicating, spinning etc.

* **Plane and Step turning:-**

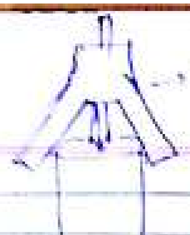
Both of these operation are simple operation and can be done by holding the job in many different ways like → b/w - centre
→ on face plate
→ in a chuck
→ on mandrel

Turning b/w centres:-

In turning operation one end of the job is held in lathe dog firmly and on the same is supported by the tip of live centre the other end of the job is supported on the dead centre. Job is revolves during the operation as lathe dog is connected to driving plate & the tool is fed again the job as shown in fig.



Centering or locating of centre is very important and during the turning operation, marking of centre is done by jenny, centre punch or combination set, surface gauge etc.



Turning on face plate or chuck :-

Face plate is usually employed when odd and eccentric job are to be supported which cannot be easily held on chuck. Work can be fixed on face plate directly or with the help of angle plate, bolts carriers depending upon the shape of the job.

Well designed fixtures are also used for holding the job in operation with face plates when mass production of same job is required or jobs are in odd shape.

Holding of job in three chuck is quite easy but in case four jaw independent chuck proper centering is must. The diff. methods are used for centering the job are as follows.

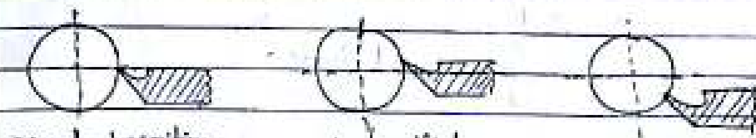
① chalk method :-

② Scriber method

③ Dial method

) Jigs AND Fixture

* Setting of turning tool :-



* Rough and finish turning :-

⇒ For heavy stock removal is made to save machining time, in this turning deep cut & heavy feed is taken.

⇒ Finish turning, after rough turning finish turning is done to the turning operation small depth of cut is used.

* Taper turning :-

For several process the diff. b/w dia. of their ends is known as taper & for flat process the diff. b/w width or length thickness of their ~~each~~ ends is known as taper.

Parts/Jobs may have internal or external taper according to the requirement.

The common method of expressing taper

ex — 1) Tapper per foot
2) Tapper per inch
3) Tapper one in x.
(1 in x)

* Standared tapper

A no. of tapper series have been standerized which are commonly used. Most common of these are as follows:—

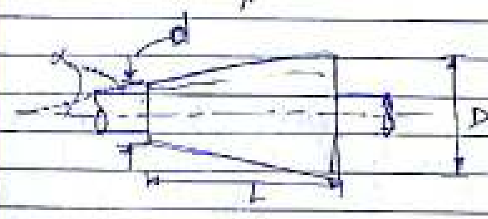
1) Morse-tapper → (5/8 inch per foot length)

2) Brown and sharp of tapper (1/2 inch per foot)

3) Ger Jarno tapper (0.6 inch per foot)

4) Matric tapper (mm per unit length)

For conical tapper:—



$x \tan\alpha = \frac{D-d}{2}/L$

$\tan\alpha = \frac{D-d}{2L}$

* Total tapper $= \frac{D-d}{2L}$

Methods of tapper turning:—

(1) Tail stock set over method
(2) By swivelling the compound rest.

(3) Using the tapper turning attachment.
(4) Form or broad nose tool.

* Tail stock set over method:—

During the tapper turning on a job the work is rotate and the tool is feed but tip of cutting tool should move at an inclination to the centre line of the job. This inclination should be equal to α i.e. 1/2 of the total tapper angle. There can be two method for accomplising these job.

(1) The job revolve in position while tool move along the straight line which is inclined to an angle α to the centre line of the job.

(2) An alternative method is that it can be shift the centre line of the job at an angle α from the original position parallel to axis of spindle.

In second method it is done by setting over the tail stock for this purpose clamping nut of the tail stock is leaven then by means of set screw provided on both front & rear sides of the tail stock the dead centre is shifted from original position to pre-determined amount of set over.

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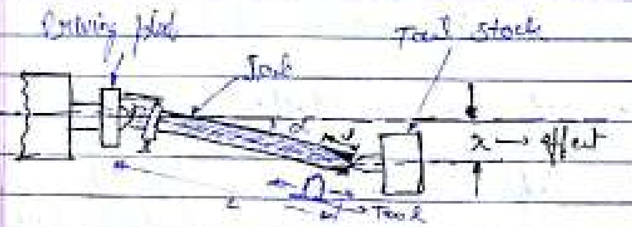


From the figure ; $x = L \sin\alpha$, as α is very small, then it can be written as -

$$\sin\alpha \simeq \tan\alpha$$

So

$$x = L \tan\alpha$$

$$\boxed{x = L \times \left(\frac{D-d}{2l}\right)}$$

$$x = \text{Total length} \times \frac{\text{Total taper}}{2 \times \text{taper length}}$$

In case of full length tapper $l = L$

$$\boxed{x = \frac{D-d}{2}}$$

Ques:=> Calculate the amount of offset of the tail stock for turning tapper on full length of a job of 12 inches long which have its two diameter as 2 inch & 1.5 inch respectively.

$$x = \frac{D-d}{2} = \frac{2-1.5}{2} = 0.25$$

Ques:=> Calculate the tail stock set over for turning a tapper on a job such that its two diameter are 80mm and 60mm. Total length of the job is 300mm & the length of tappered portion is 200mm only.

$$x = L \times \left(\frac{D-d}{2l}\right)$$

$$= 300 \times \left(\frac{80-60}{2(200)}\right)$$

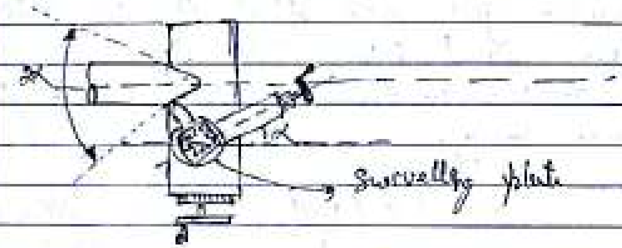
$$= 15 \text{ mm}$$

(*) By swivelling the compound rest / compound rest slide method (*)

Short tapper may be cut by setting the compound rest at an angle and hand feeding using the compound feed screw.

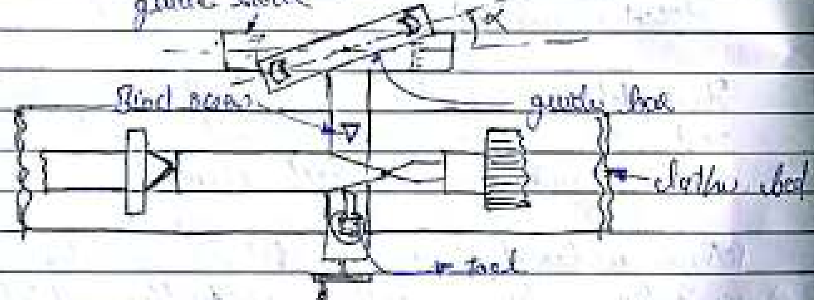
The compound rest on lathe has a circular base called swivelling plate, this plate can be rotate to any desired with the job. There are a dial indicating the angles on swivelling plate which helps in easy setting of angle during tapper operation.

It is very easy method but short length can be cut only & it is about (75–100) mm



$$\alpha = \tan^{-1}\left(\frac{D-d}{2l}\right)$$

* By using taper turning attachment *



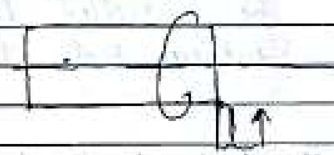
⇒ In this method special attachment for taper is provided at the rear end of the lathe bed. The attachment has two part, one is the guiding block which is parallel to lathe bed & the second one is moveable in angular direction. The cross slide is made free from screw by opening binding screw and connected to guiding bar. By doing so the cutting tool can be guided through out the length which has to be tappered.

Advantage:-
Easy & quick setting.
Tool is no requirement of high skilled labour.
Very steeve taper on long w/p may be (Accured)
It provide better surface finish.

* By using a broad nose form tool *

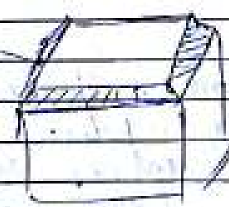
In this method of taper turning a broad nose tool having straight cutting edge is set on to the w/p at (half taper angle). with the help of this method short taper of short length can be turned.

* Facing :-



Facing is done at the end of the job.
facing is the act of cutting a face, which is a planar surface, onto the workpiece.

* Chamfering :-



It is a process of end edges removal of the job.

* Grooving :-
A long, narrow cut or indentation in a surface, as the cut in a board to receive the tongue of another board.

* **Parting off :-** Parting is the process of cutting off a piece of stock while it is being held in the lathe. This process uses a specially shaped tool bit with cutting edge similar to that of a square.

* **Drilling :-**
Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid material.

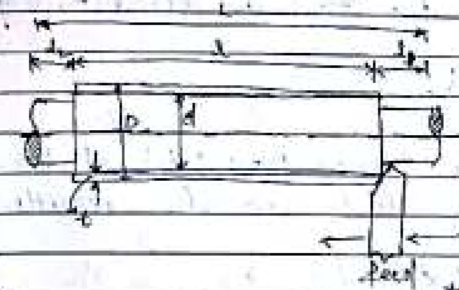
* **Boring :-** In machining, boring is the process of enlarging a hole that has already been drilled by means of a single-point cutting tool.

* **Knurling :-** Knurling is a manufacturing process, typically conducted on a lathe, whereby a pattern of straight, angled or crossed lines is cut or rolled into the material.

* **Forming :-**
Forming processes are particular manufacturing processes which make use of suitable stresses to cause plastic deformation of the materials to produce required shapes. During forming processes no material is removed.

N → Speed of job in rpm.
n → no. of passes.
L_1 → Total distance in mm

Calculation based on Speed, feed and Depth of cut :-



From the fig. of

L_1 = distance required for feeding the tool crosswise, L_1 = travel of cutting tool, d in depth of cut in mm, f_1 feed in mm/revolution.

When a job is turned on lathe m/c considering the above fig. t can be written as

$$t\,(mm) = \frac{D-d}{2}$$

and the cutting speed which is defined as distance travelled per minute by a point on the circumference of the work in direction parallel to the direction of feed.

This speed can be calculated by the following relationship -

$V = \frac{\pi D N}{12}$ feet/min. $\quad V = \frac{\pi D N}{1000}$ m/min rpm $\quad , V = \frac{DN}{3/4}$ m/min rpm

where, V = cutting speed in m/min
D = diameter in mm
N = rpm.

Ques ⇒ Determine the cutting speed in m/p of machining of 200mm dia. rotating at speed of 100 rpm

In short form it can be written as distance travelled by the tool in direction of feed

$L = l + l_1 + l_2$

If there is n passes then total distance travelled by tool can be written as

$$L_1 = L \times n$$

Also the amount of feed per minute can be calculated by the following relationship.

$$f = f_1 \times N$$

$f_1 \rightarrow$ feed in mm per revolution.

So, the time t in minutes required for the tool to move through the length L_1 can be written as -

$$T = \frac{L_1}{f} \text{ minutes}$$

$$T = \frac{L \times n}{f_1 \times N}$$ **

Q → A hollow cup of 10 mm outside dia and 150 mm length is held on a centre lathe centres and turned all over in four passes. If the approach length is 20 mm and over travel is 12 mm. Average feed is equal to 0.8 mm/revolution, cutting speed is 30 m/min. Calculate the machining time.

$$T = \frac{L \times n}{f_1 \times N}$$

$$V = \frac{\pi D N}{1000} = \frac{\pi \times 60 \times N}{1000}$$

$$\frac{30 \times 1000}{\pi \times 60} = N$$

$N = 159.2$

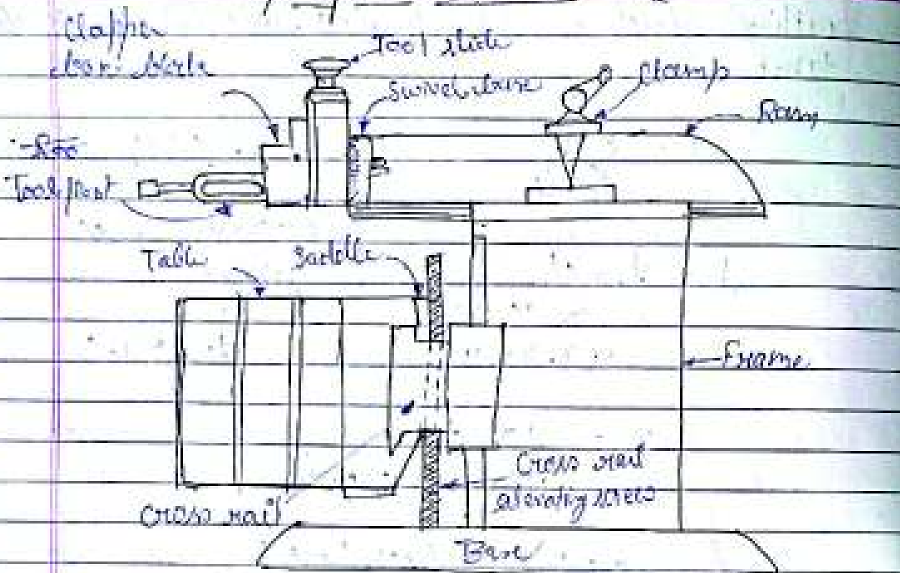
$f = f_1 \times N$
$= 0.8 \times 159.2$
$= 127.324$

~~$T = \frac{150 \times 4}{127.324 \times 150}$~~

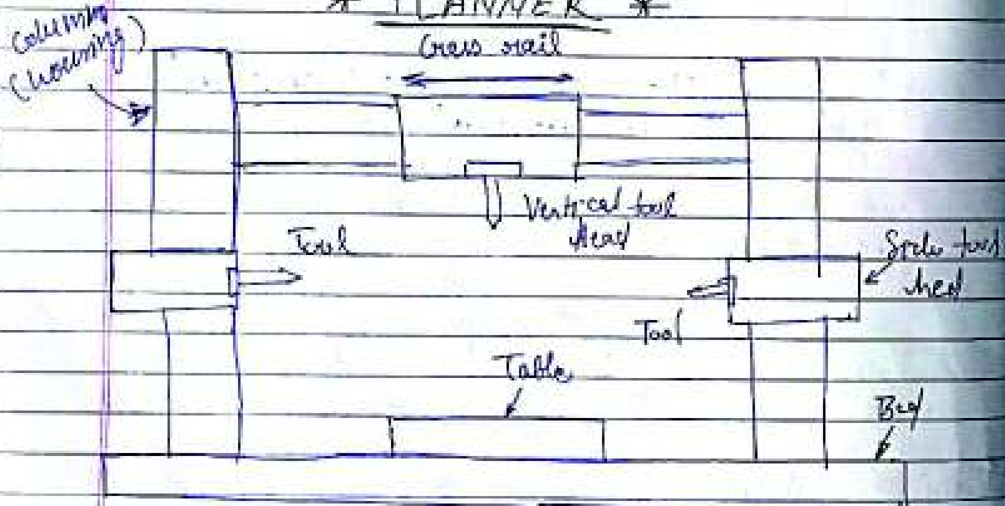
for $L = l_1 + l_2 + l_3$
$= 100 + 20 + 12$
$= 132$

$$T = \frac{132 \times 4}{127.324} = 5.7 \text{ second.}$$

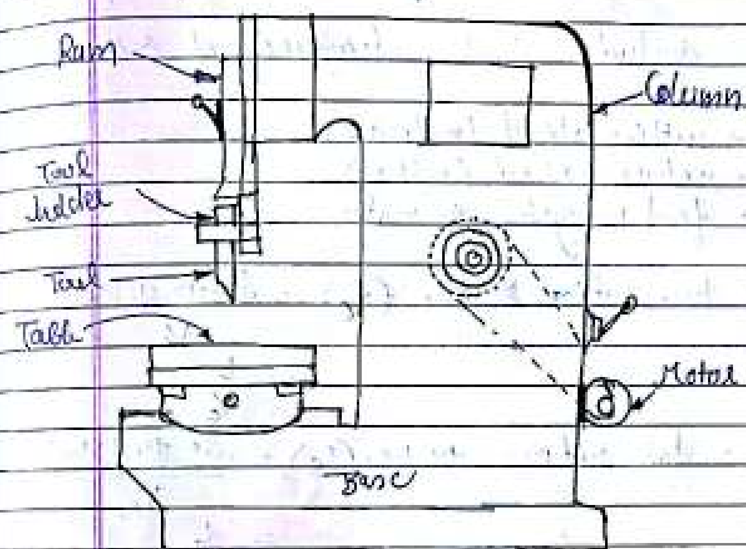
Shaper Machine (Tool ⟷)



* PLANNER *



Slotting Machine (Slotter) (Tool ↕)



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Machining time for Shaper

Let 'l' be the length of stroke (m) of Shaper where,

L includes tool clearance at both ends

Let V_c → cutting speed (m/min).

V_R → return speed (m/min)

f → feed per cycle in meter

∴ time for cutting stroke (t_c) = $\frac{\text{length of stroke}}{V_c}$

$= \frac{L}{V_c}$

again

time for return stroke (t_R) = $\frac{\text{length of stroke}}{V_R}$

$= \frac{L}{V_R}$

Total time for one-cycle (T) = $t_R + t_c$

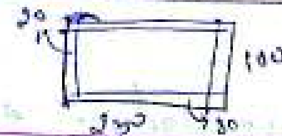
Now, if 'W' is width of w/p with clearance included either side then no. of ~~stroke~~ cycle required

$= \frac{W}{f}$

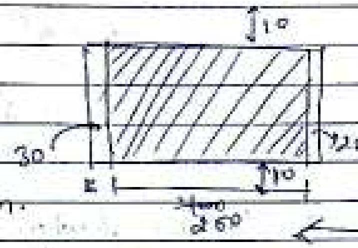
So, the machine time for whole job (T_m)

i.e. T_m = no. of cycle × Total time

$= \frac{W}{f} \times T$



Ques> Calculate the time to machine 250 mm long plate 100 mm wide. Tool clearance at each of stroke is 30 mm & 20 mm respectively. Cutting speed is 10 m/min, return speed is 20 m/min. Feed is 1 mm/cycle & the distance tool moves on either side of work in width direction is 10 mm each.



$L = 250 + 30 + 20 = 300$ mm

$W = 100 + 10 + 10 = 120$ mm

$t_c = \frac{300}{10 \times 1000} = 0.03$ m/min.

$t_R = \frac{300}{1000 \times 20} = 0.015$ m/min.

Total time = 0.045

$T_m = \frac{W}{f} \times T = \frac{100}{1} \times 0.45 = 4.5$ ~~m/~~

(4.5 Ans)

Ques> A w/p 144 cm × 68 cm requires one cut. The cutting speed is 1050 cm/min & return speed is in ratio of 2:1. The feed is 1.5 mm for cutting stroke. How long will the w/p take to get planed.

(91)

V_c = 1050 cm/min.

$\frac{V_R}{V_c} = \frac{2}{1}$

$V_R = 2 \times V_c$

$= 2 \times 1050 = 2100$ cm/min ~~9.32~~

t_c = 0.1372

t_R = 0.069

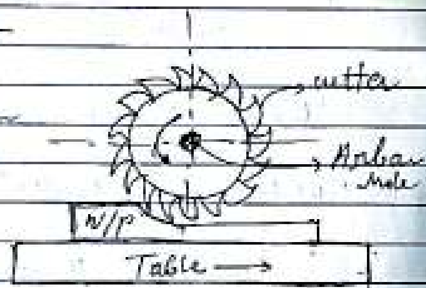
T. Time = 0.2056

T_m = 9.32 cm/min = 93.205 m/min

* Milling Machine *

Milling is a machining process in which removal of metal takes place due to the rotating multipoint cutting tools. In milling process tool is in rotating condition and the job is fed against the rotating tool.
It is generally used for small & medium sized sized job.
A large variety of machining operation can be obtained.

⇒ Working principle :-



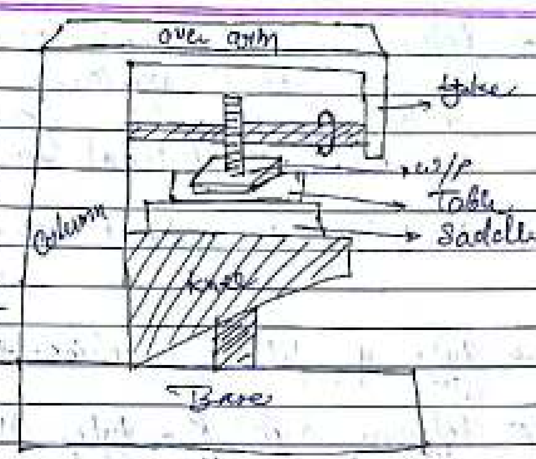
A milling M/c is a power driven machine. The metal is cut by means of multipoint cutting tool by feeding the w/p against the rotating cutter.

The optimum cutting effi can be achieved by selecting proper cutter design, suitable M/c capacity, w/p requirement, work holding fixture design.

On this ways metal can removed from small and medium ~~metal~~ job with the help of milling M/c is very economical ways.

(1) Arbor :-

It is accurately made shaft with various grooves for providing the space for cutters. It rotate the cutting tool and support the cutting tool with the help of yoke.



Horizontal column & knee type M/c

(2) Over arm :-

It is mounted on tope of the column and used for support the arbor.

(3) Table :- It contains T-slots mounted on tope of the ~~table~~ saddle and hold the w/p

(4) Knee :- It contains feed change gearing & mounted ~~on saddle~~ with the screw yoke. knee can be elevated up & down direction by screw jake.

(5) Saddle :- It provide

(6) Base :- It heavy casting of cast iron, work as foundation and support the for column & screw jack.

(7) Column:- It is main casting of milling. It support various parts and control unit like gear mechanism, drive mechanism & electrical etc.

At its top its support over arm.

* Types of Milling machine *

(A) Column and Knee type Milling M/c
(i) Hand milling M/c
It is smallest & simplest of all milling M/c. All the operation except rotation of arbor are performed by hand.

Specially it is used full in small components milling like hexagonal & square heads on bolts, bolts, cutting slots, cutting of keys ways etc.

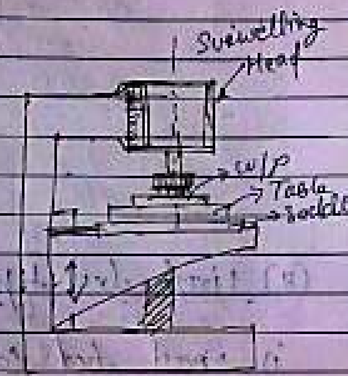
(ii) Plane horizontal milling M/c

It is very common milling M/c. It is having a arbor horizontal position that why it is named as horizontal milling M/c. Here column serve as housing for electrical, main drive & spindle etc.

knee act as a support for saddle, work table and other accessories like indexing head etc.

The table can be given straight motion in three direction - horizontal, vertical, & longitudinal, but cannot be swivel moveble.

(iii) Vertical milling M/c.



Its name is due to vertical position of spindle.

These M/c are available in both type - fixed bed type and column & knee type.

The main parts of its are:- swivelling Head,

In this M/c "over arm" an integral part of it & having a fixed or swivelling head at its front end.

In the fixed type head tool moves in only up & down direction were as in swivelling head it can be move in angular direction too.

Mostly used in face milling operation.

* (iv) Universal milling M/c

A milling machine having a table fitted with all motions and a dividing head with change gears so that it can perform any

Date 22/3/2017

Types of milling operation.

(B) Fixed bed type or Manufacturing type

i) Fixed bed Plain milling m/c :-

- It differs with column & knee types of milling m/c in terms of fixed bed in which table is mounted —

Instead of saddle & knee

- Table cannot move up & down or even in cross wise direction

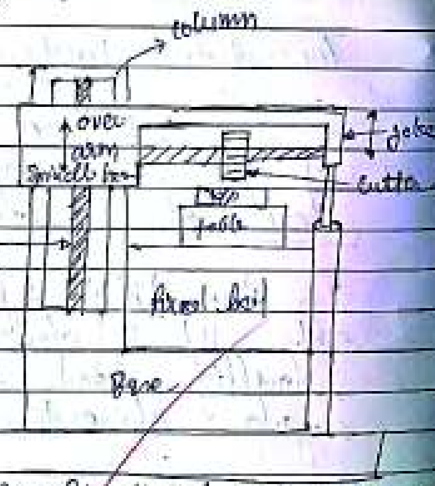


Fig: Fixed bed plain milling m/c

- Spindle carrier or spindle head can be moved up & down along the column ways to adjust the tool to the work

ii) Duplex head fixed bed type Milling :-

It is another useful form of fixed bed type milling m/c where two spindle head or carriers can be move up & down direction along the column simultaneously or individualy.

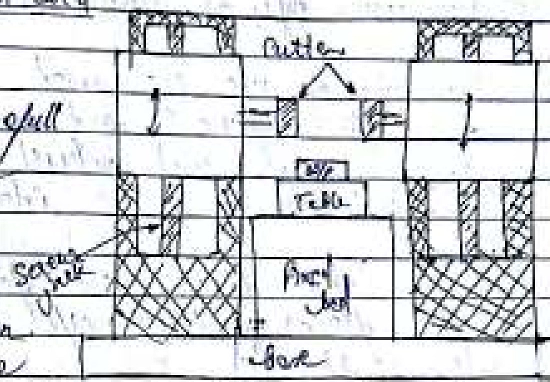


Fig:- Duplex Head Fixed bed type Milling M/c

(iii) Plainer type Milling Machine :-

A planer is a type of metalworking machine tool that uses linear relative motion b/w the workpiece and a single-point cutting tool to cut the work piece. A planer is similar to a shaper, but larger and with workpiece moving, whereas in a shaper the cutting tool moves.

Application —

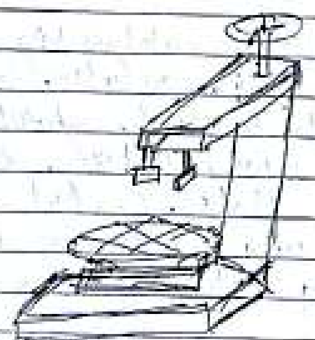
- Generally accurate flat surfaces
- cutting of slots

(c) Production type or continuous milling M/c

This types of M/c are used in mass production of M/c component and its construction is heavy and robust and the process is continuous in no ideal time.

It has three time more production rate than the plane milling M/c. It also require less space.

Example :- Drum type milling, rotary type, Tracer type controlled milling M/c.



(d) Special purpose type milling M/c

When milling M/c are design for particular or specific purpose then this category belong to special purpose milling M/c. They may be used for greater accuracy, better finish or some other purposes like circular motion of cutting tool.

Some special purpose milling M/c are -

1) Thread milling M/c →
2) Gear milling M/c →
3) Planetary milling M/c →

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* Milling machine attachment *

> To hold the cutter - Arbors, Collets, adaptor etc.
> To hold the work piece - Vice, Circular table, indexing head, tail stock etc.
> To acts as Auxiliary spindle - Vertical milling attachments, spiral milling, slotting attachments etc.

* Milling methods * Milling can be performed by two methods -
① Upon conventional milling.
② Down milling.

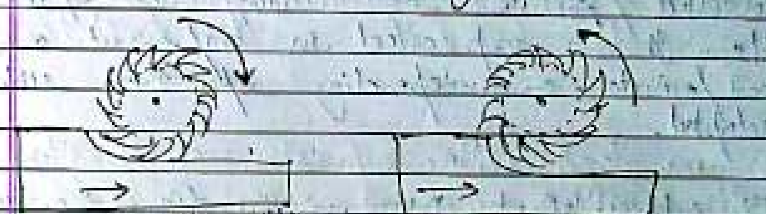


Fig: Up milling   Fig: Down milling.

Up:-
=> The cutter rotates in direction opposite to that in which the work (Job) is feed.

=> Chip thickness increase from the start at end point of cutting.

=> Use for casting and forging.

* Down

In this milling operation cutter direction &

work feeding direction are same.

- Chip thickness decreases from start pt to end pt.
- This milling method is used for finishing operation & small finishing operation.

* Cutting speed & feed *

Cutting speed :-

Cutting speed of milling m/c is the distance travelled / minute by cutting edge of the cutter. It is expressed in m/minute or feet/minute depending upon the unit adopted.

Now, suppose that D mm is the dia of the cutter and it makes N-revolution per minute.

So, distance travelled by the cutter in one revolution = πD mm

So, for N-revolution total distance travelled

$= \pi D N$ mm/minute

Cutting speed $= \frac{\pi D N}{1000}$ m/min. or

$= \frac{\pi D N}{12}$ feet/min.

{Q- If milling cutter 100mm dia runs at 180 rpm. Calculate the cutting speed.}

Feed :-

It is distance travelled by the table in any direction (mm).

Feed can be given to table by hand or automatic machine.

Feed can be expressed in three following ways-

(i) feed / minute
(ii) feed / tooth
(iii) feed / revolution.

- (i) ⇒ It is table travelled in mm in one minute in any direction (mm/min.)
- (ii) ⇒ It is table travelled in mm during the period of angular travel of tooth corresponding distance b/w the cutting edges of two adjacent teeth (feed / tooth)
- (iii) ⇒ It is table travel in mm during the period of cutter one full revolution.

Note :-

Feed/revolution = feed/tooth × T
where, T = no. of teeth

Feed / minute = feed/revolution × N
= feed/tooth × T × N

* Estimation of milling time *

⇒ Factors for milling time:
① Total length ② approach
③ Over run ④ Number of cut
⑤ Cutting speed ⑥ feed per minute

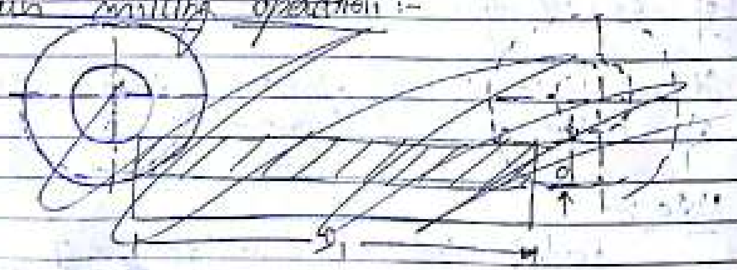
⇒ Total length :-
It is the length of the job to be cut

⇒ Approach :-
It is distance to move by cutter before occurring the full depth of cut

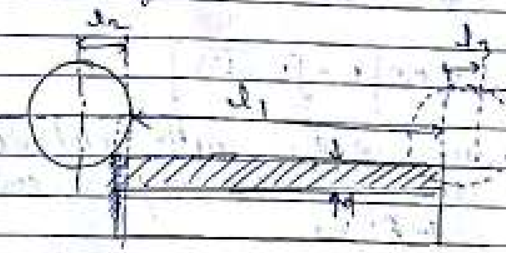
⇒ Over run :-
Distance moved by cutter after the job length to be clear of the job.

* Now considered milling operation on plane & face milling :-

⊳ Plain milling operation :-



⊳ Plane milling operation.



If l_1 is length to be cut, l_2 is approach length and l_3 is over run in mm then total length traveled by the cutter -

Total length travel by cutter [L]

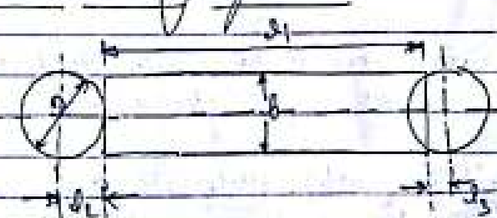
$$L = l_1 + l_2 + l_3$$

In case of plane milling m/c

D ⇒ cutter diameter
d = depth cut

Then, $l_2 = \sqrt{d(D-d)}$ mm

⊳ Face milling operation :-



Scanned by CamScanner

Let b → is the width of job and
D → is the cutter diameter

Then $l_2 = 0.5\left[D - \sqrt{D^2 - b^2}\right]$

The over run of the cutter depending upon the size of m/c may be can be taken as 1-6 mm

Now, if 'n' be the no. of cut and f - feed in mm/min.
Then the milling time (T)

$$T = \frac{n \times L}{f} \text{ min.}$$

Note :- For finding out the total floor time, handling time should also be added to the actual m/c time.

* Milling Cutters *

① Proper selection, use and care must be practiced for best result

② Constantly observe how milling m/c performs with different cutters and clearance.

* Miller Cutter Materials *

- Cutter quality, tough to resistance shock

- Harder than metal being machined.
- Resist heat & abrasion of cutting.
- Most only of

High-speed steel :-
Cemented - carbines:-

Classification of milling tool

① Plain milling cutter ⑥ Angle milling cutter
② Side milling cutter ⑦ Formed milling cutter
③ End milling cutter ⑧ Woodruff key milling
④ Face milling cutter ⑨ Fly cutter
⑤ Metal slitting cutter ⑩ T-slot milling cutter

① Plain milling cutter
Most widely used

ⓐ Light - duty plain milling cutter
ⓑ Heavy - duty plain milling cutter (Helix < 45°)
ⓒ High - Helix Plain

② Side milling cutter (straddle milling)
- Half - side milling cutter
- plain side milling
- straggered
-

③ Face milling.
face
Shell types milling cutter

⑤ Formed cutter
- concave
- Convex
- Gear Tooth
⑥ Metal slitting cutter
⑦ End milling

④ Angular milling cutter.

Sifian Indian Tool room

Date 29/3/2017

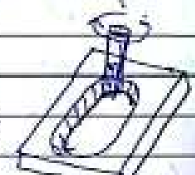
Milling operation

Peripheral Milling
① Slab milling
② Slotting
③ Straddle milling
④ Slitting (divide the one work into two par)

⇒ Face milling (cutter to ⊥ to the machined surface)
rough machining
- High production rate
- Requires significant power.

⇒ End milling
End mills with flat ends (so called square-end milling)

⇒ Pocket Milling

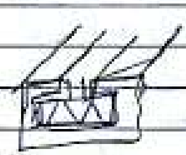


Another form of end milling used to mill shallow pockets into flat parts.

⇒ Angular Milling
- Horizontal milling machine

⇒ Gang Milling

⇒ Slot Milling



⇒ Milling of complex surfaces

3/4/2017

INDEXING

By indexing means division of job periphery into a desired no. of equal division. It is done by horizontal movement of the crank such that the job rotates through a definite angle after each cut is over.

It is possible to divide the periphery of w/p into any no. of equal parts.

⇒ There are generally three types of head is used to perform indexing.

① Plain dividing head
② Universal dividing head
③ optical dividing head

~~By indexing~~

The following methods of indexing are commonly used :-

(i) Plane or simple indexing

Plane indexing involves the use of crank, worm wheel, and index plate. Worm wheel carries 40 teeth and worm is single start. One wheel is directly mounted of spindle.

Since, the worm has single start thread and

and the worm wheel has 40 teeth. Therefore with one turn of crank the worm wheel rotates through one pitch i.e. $\frac{1}{40}$ of revolution.

Thus, the crank will have to rotates through 40 turns in order to rotate the work through one complete turn.

The holes in the index plate serves to sub-divide the rotation of crank.

Crank movement $= \frac{40}{N}$ → no. of division

In case of fraction the numerator denotes the no. holes to be moved & the denominator denotes the no. holes of on the circle to be used.

Ques It is required to divide the periphery of job into 60 equal division find the crank movement.

Crank movement $= \frac{40}{N}$

$$= \frac{40}{60} = \frac{2}{3} \times \frac{6}{6} = \frac{12}{18}$$

Ques Required 85 division on a plate find the velocity plate movement.

Compound Indexing:

This method employed when no. of division is required is beyond the range of simple indexing.

It involves two seperat movement by turning the crank a definit amount in one direction.

By turning the index plate and crank both either in same or reversed direction.

Procedure :-

1. Factorise the no. of division required.
2. Factorise the standard no. of teeth
3. Select for trial any two circles on the same plate and on its same side, factorise the difference.
4. Factorise the no. holes one of one circle circle.
5. Factorise the no. of holes on the other circle.

After finding the above values place all of them in following ways.

Factors of division required × factors of the diff. of selected holes circle

factor of 40 × factors of first circle × factor of 2nd circle

Check

78

(1) If the above expression gives one as indicator indicates the circle selected are correct

If not then repeat the process.

If $\frac{1}{x}$ varies then the required indexing movement will be $\frac{x}{a} - \frac{x}{b}$

or

$\frac{x}{b} - \frac{x}{a}$

where a, b denotes no. of holes in two circle

The positive part of the two indicates the movement of crank in one direction & -ve part denotes the movement of the plate and crank in opposite direction.

(3) After finding the above expression calculate

$\frac{x}{a} + \frac{x}{b} = \frac{40}{N}$ → no. of division required

Q) Calculate the compound indexing for 87 division