MACHINE TOOL ① GATE ESE-IES

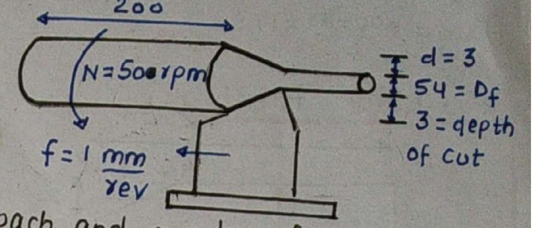
* Parameter of Machining

(i:-) Cylindrical Turning :- Axial feed [feed is // to Axis of Revolution]

$$\boxed{t_m = \frac{L_e}{f N} = \frac{L_a + L_w + L_o}{f N}} = \text{min}$$

L_e → mm

$\frac{mm}{rev} \times \frac{rev}{min} = \frac{mm}{min} =$ feed Velocity or Cutting Velocity



* No approach and overtravel

$t_m = \frac{L_e}{f N} = \frac{200}{1 \times 50\bullet} = 4$ min

* Cutting Velocity :-

$\boxed{V = \frac{\pi D N}{1000}}$ D = mm, V = m/min, N = rpm

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

* If V_{max} → given

$\boxed{N = \frac{V \times 1000}{\pi \times D_{max}}}$

If V_{min} → given

$\boxed{N = \frac{V \times 1000}{\pi \times D_{min}}}$

If V_{avg} → given

$\boxed{N = \frac{V \times 1000}{\pi \times D_{avg}}}$

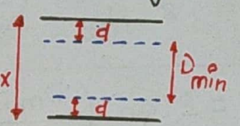
* If Nothing mention, Velocity is max^m or min^m then take Average

$50 \xrightarrow{\text{depth of cut} = 3} 44 \Rightarrow \frac{50+44}{2}$

$D_{avg} = 47$

* Depth of Cut (d) in Case of Turning and Boring

(a) Turning

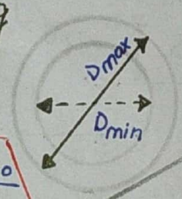


$N_{turning} = \frac{V \times 1000}{\pi \times D_{max}}$

$D_{max} - 2d = D_{min}$

$\boxed{d_T = \frac{D_{max} - D_{min}}{2}}$

(b) Boring



$\boxed{N_{boring} = \frac{V \times 1000}{\pi \times D_{min}}}$

$\boxed{d_B = \frac{D_f - D_i}{2}}$

Depth of Cut

(a) Turning

$d_T = \frac{D_i - D_f}{2}$

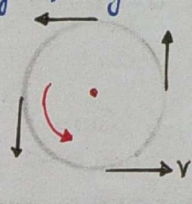
(b) For Boring

$d_B = \frac{D_f - D_i}{2}$

Note:- (1) $\boxed{T_m = \frac{L_e}{f N} \times n}$ {where n = Number of Pass depends upon max^m depth of cut}

(2) If V = given then Calculate N step by step

(3)



V = tangential Velocity or Peripheral Velocity or Surface Velocity

F_c = tangential Force (Cutting Force)

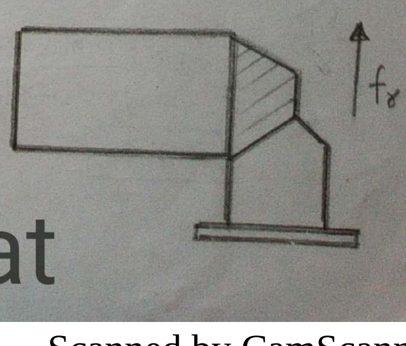
$\boxed{\therefore \text{Power} = F_c \times V}$

This Formula is applies when the direction of F_c and V are Same

2:- Facing

workpeice गोल है, आधे रास्ते जायेगा, काम पूरा हो जायेगा।

$\boxed{t_m = \frac{D/2}{F_r N}}$

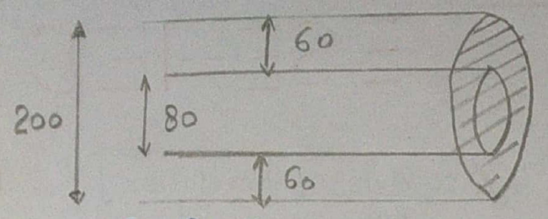


f_r = feed is ⊥ to Axis of Revolution.

D = Diameter of Workpeice.

Mradul Rawat

Question :- Facing



$F = 0.1$ mm/rev

$V = 200$ m/min → Nothing given max/min then take Avg Velocity

$t_m = ??$

$D_{avg} = \frac{200+80}{2} = 140$

$$N = \frac{200 \times 1000}{\pi \times 140} = 454.72 \text{ mm}$$

$$t_m = \frac{D/2}{F_r \times N} = \frac{120/2}{0.1 \times 454.72} = 1.319 \text{ min.}$$

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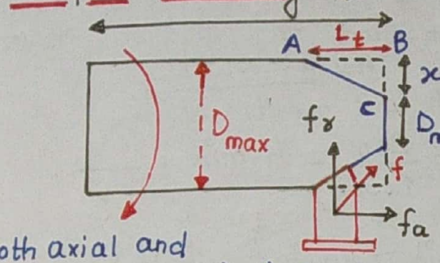
* Taper Turning



L_t = length of taper

L_w = length of Workpeice

$$t_m = \frac{AC}{fN}$$

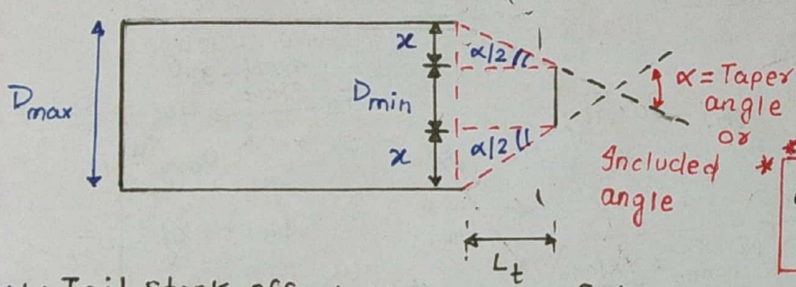
$$f = \sqrt{f_a^2 + F_r^2}$$

$$AC = \sqrt{L_t^2 + x^2}$$

$$\boxed{(t_m)_{taper} = \frac{\sqrt{L_t^2 + x^2}}{\sqrt{f_a^2 + f_r^2} \cdot N}}$$

Both axial and radial component of feed is provided.

(a) Calculation of taper Angle



$D_{max} - D_{min} = 2x$

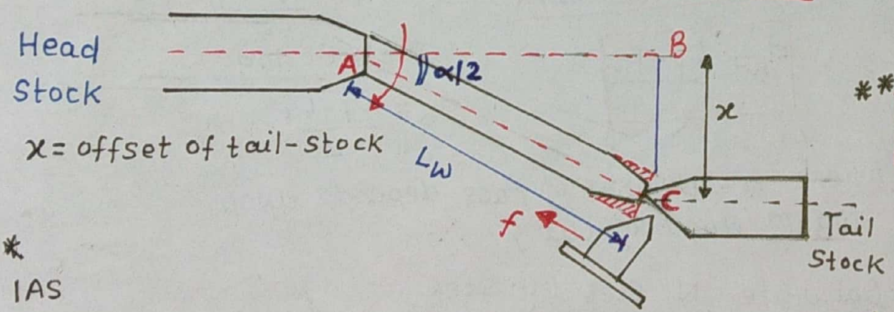
$D_{max} - 2x = D_{min}$

$$x = \frac{D_{max} - D_{min}}{2}$$

$$\tan\frac{\alpha}{2} = \frac{x}{L_t} = \frac{D_{max} - D_{min}}{2L_t}$$

$$* \boxed{\alpha = 2\tan^{-1}\left(\frac{D_{max} - D_{min}}{2L_t}\right)}$$

(b) Tail stock offset Method or Setover method



x = offset of tail-stock

$$\sin\frac{\alpha}{2} = \frac{x}{L_w}$$

$$** \boxed{x = L_w \sin\frac{\alpha}{2}}$$

*
IAS

Ques :- $D_{max} = 50$ mm $D_{min} = 38$ mm, $L_w = 300$ mm, If taper is done along entire length, the tailstock offset (in mm)

Solu :- $x = L_w \sin\frac{\alpha}{2} \Rightarrow L_w \tan\frac{\alpha}{2}$

$$x = L_t \tan\frac{\alpha}{2}$$

but $\tan\frac{\alpha}{2} = \frac{x}{L_t} = \frac{D_{max} - D_{min}}{2L_t}$

$$x = \cancel{L_t} \times \frac{D_{max} - D_{min}}{2 \times \cancel{L_t}} = \frac{50 - 38}{2}$$

$$\boxed{x = 6}$$

$\frac{\sin\theta}{\cos\theta} = \tan\theta$

If θ is very small $\cos\theta = 1$

$\sin\theta = \tan\theta$

$\sin\frac{\alpha}{2} = \tan\frac{\alpha}{2}$

$\left[\sin\frac{\alpha}{2} = \frac{x}{L_w}\right.$ and $\tan\frac{\alpha}{2} = \frac{x}{L_t}$

$\frac{x}{L_t} = \frac{x}{L_w}$

$\boxed{L_w = L_t}$

Threading :- It is Continuous Form of helical ridges Formed over Cylinder or Frustum of Cone.

Formed over Cylinder ⟶ Straight or parallel thread

Formed over Cone ⟶ Tapered thread.

High quality thread ⟶ Thread chasing process

↓

The lathe Used For thread chasing is Swiss Automate

Thread are Formed by
(a) Single point threading tool
(b) Form tool application.

Application of thread
(a) Fastening of two objects.
(b) Motion transmission.

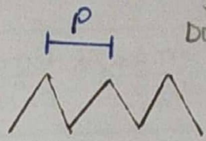
* Single point thread tool should ideally have Zero rake angle but practically (−)ive rake angle is Used.
* Thread cutting is a slowest Speed operation in lathe.

अगर Ques में single या Double start कुछ नहीं लिखा तो By default single start मान लेंगे।

→ Machining Calculation

$$\boxed{t_m = \frac{L_e}{fN} \times n}$$

f = depend upon pitch
pitch is the distance between two adjacent peak and Valley



n = no of Cuts

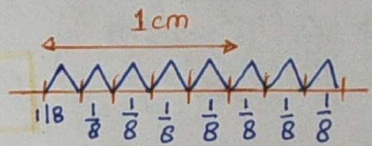
① Single start thread
1 rev = 1 thread
F = 1P

② Double start thread
1 rev = 2 thread
F = 2P

③ Triple start thread
1 rev = 3 thread
F = 3P

Note :- If pitch is Not given and No of thread = 8/cm

$p = \frac{1}{8}$ cm



Gate :- To produce double start thread of pitch 2mm the feed (mm/rev) is $F = 2P = 2 \times 2 = 4$ mm/rev

Gate :- Find the time for threading on 3cm Spindle of M.S for length of 15cm The Number of thread are Cut by 3/cm. The lathe run at 88 rpm and No of Cut for M.S are 7. Assume approach and over travel are 0.5cm each

Solu :- $t_m = \frac{L_e}{fN} \times n$

$L_e = 15 + 0.5 + 0.5 = 16$

$n = 7$

No of thread = 3/cm
pitch = 1/3

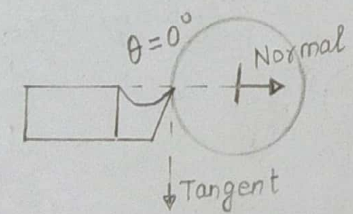
$N = 88$ rpm

$$t_m = \frac{16}{\frac{1}{3} \times 88} \times 7 = 3.81 \text{ min}$$

Tool Setting Errors

(a) Ideal Condition

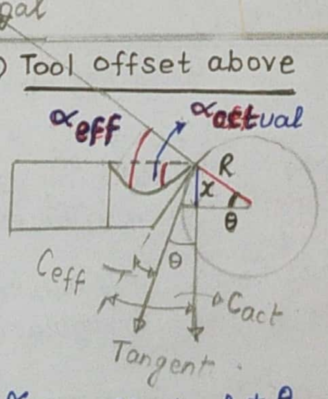
$\theta = 0°$ $x = 0$ (offset)



(a) $\alpha_{eff} = \alpha_{actual}$

(b) $C_{eff} = C_{actual}$

(2) Tool offset above



(a) $\alpha_{eff} = \alpha_{actual} + \theta$

(b) $C_{eff} = C_{act} - \theta$

Rake ∠ ↑ , Clearance ∠ ↓

$\theta = \sin^{-1}\left(\frac{x}{R}\right)$

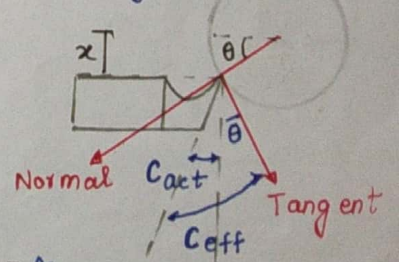
x = offset distance

θ = offset angle

(3) Tool offset Below

α_{eff} & α_{act} are rake angle

C = clearance angle



(a) $\alpha_{eff} = \alpha_{act} - \theta$

(b) $C_{eff} = C_{act} + \theta$

Rake ∠ ↓ , Clearance ∠ ↑

$\theta = \sin^{-1}\left(\frac{x}{R}\right)$

$$\boxed{\alpha_{eff} + C_{eff} = \alpha_{act} + C_{actual}}$$

Boring

Rake angle ↓

Clearance angle ↑

Ques:- While turning a diameter of 90 mm, the turning tool is set below centre line by 5mm, if actual rake angle is 10° and actual clearance angle is 5°, find the effective rake and clearance angle.

Solu:- Tool offset below

(4)

$x = 5mm$ $\alpha_{act} = 10°$ $C_{act} = 5°$ dia = 90 m $\alpha_{eff} = ?$ $C_{eff} = ?$

$$\theta = \sin^{-1}\left(\frac{x}{R}\right) = \sin^{-1}\left(\frac{5}{45}\right) = 6.38°$$

$$\alpha_{eff} = \alpha_{act} - \theta$$

$$\alpha_{eff} = 10 - 6.38 = 3.62$$

$$C_{eff} = C_{act} + \theta = 5 + 6.38 = 11.38°$$

* Speed Selection

* The different speed on a lathe are provided in geometric progression.

$$\boxed{N_{max} = N_{min}\, r^{n-1}}$$

Speed range Ratio

$$\boxed{\frac{N_{max}}{N_{min}} = r^{n-1} = \frac{V_{max}}{V_{min}} \times \frac{D_{max}}{min}}$$

Note:- If Machinability indices for work material are 50 means Cutting speed = 50

n = No of speed available in gear box

N_{max} = Max^m speed in gear box

N_{min} = Min^m speed in gear box

r = Common ratio.

Metal Removal Rate (mm³/min)

$$\boxed{MRR = \frac{Volume}{Time}}$$

$$Volume = \frac{\pi}{4}(D_i^2 - D_f^2) \times L$$

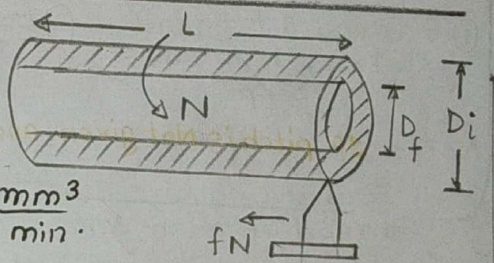
$$t_m = \frac{L}{fN}$$

$$= \frac{\frac{\pi}{4}(D_i^2 - D_f^2) \times \cancel{L}}{\cancel{L}/fN}$$

Area of x-s/c Axial Speed

$$\boxed{M.R.R = \frac{\pi}{4}(D_i^2 - D_f^2) \times fN} \ \frac{mm^3}{min}$$

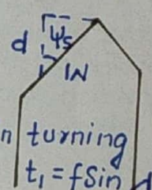
mm^2 $\frac{mm}{min}$



$$M.R.R = \pi\left[\frac{D_i + D_f}{2}\right]\left[\frac{D_i - D_f}{2}\right] fN$$

$$= \pi D_{avg}\, d_T\, f N \quad \to V_{Avg}$$

$$\boxed{M.R.R = f\, d\, V_{avg}}$$



$\sin\lambda = \frac{d}{w}$

$w = \frac{d}{\sin\lambda}$

but in turning $t_1 = f\sin\lambda$

but $A = w \times t_1$

$= \frac{d}{\cancel{\sin\lambda}} \times f \cancel{\sin\lambda}$

mm^2 $\boxed{A = f \times d}$

In term of Cutting Velocity [2-D Analysis]

$$\boxed{M.R.R = f\, d\, (V \times 1000)\ mm^3/min}$$

m/min → mm/min

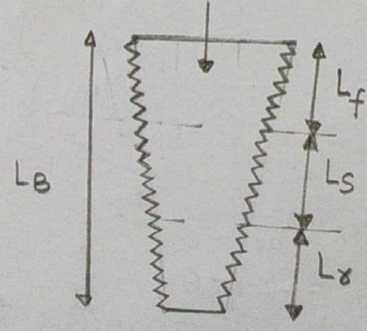
$$\frac{mm}{rev} \times mm \times \frac{m}{min} = \frac{mm^3}{min}$$

Grinding → Highest cutting speed.

(1) Cut gears (2) internal & external machining (3) enlarge circular & non circular holes (4) cut keyways etc

Broaching:- Least cutting speed

Orthogonal cutting tool

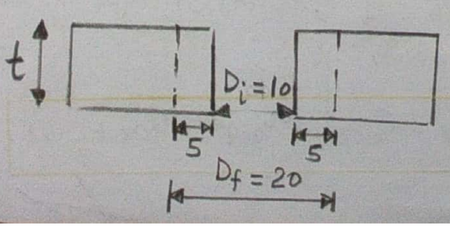


→ Will not remove any material

→ Reduce surface irregularities

→ Removes very less material and involves partial finishing

→ Remove maximum material



* Broaching is highly accurate and high accuracy of surface finish.

→ No material Removal [because they remove Surface roughness or Surface Irregularity and Surface Irregularity are in micron level which Neglected.

→ Spline hole are made by Broaching

→ Single point Cutting tool may be Orthogonal and may be oblique

oblique Cutting → twist drill, helical milling Cutter

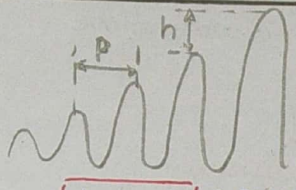
Orthogonal Cutting → Broaching, shaping, planning, slotting

$$\boxed{t_m = \frac{L_e}{V} = \frac{t+L_r+L_s+L_f}{V} = \frac{t+L_B}{V}}$$

L_B = Cutting length of broaching

t = thickness of Workpeice

$L_B = L_r + L_s + L_f$



$\boxed{d = n \times h} \Rightarrow n = \frac{d}{h}$

$L = n \times p$

$\boxed{L = \frac{d}{h} \times p}$

(a) Rough teeth

$L_r = n_r \times P_r$

$\boxed{L_r = \frac{d_r}{h_r} \times P_r}$

$L_s = n_s \times P_s$

$\boxed{L_s = \frac{d_s}{h_s} \times P_s}$

$\boxed{L_f = n_f \times P_f}$

$d_f = n$

Total depth of Cut $= d_r + d_s$

$\cancel{d_f} = n_f \times \cancel{h_f}$ → 0

$n_r > n_s > n_f$

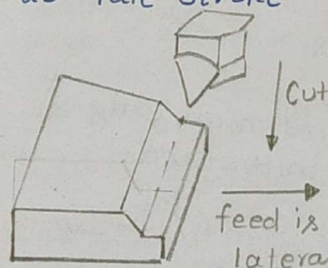
n = no of teeth.

Shaping [Size of shaper is given by Stroke length

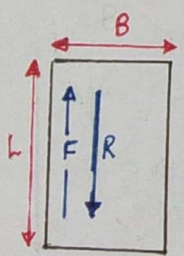
→ material is removed From Surface by using Single Point Reciprocating tool

→ Cutting motion provided to tool whereas lateral feed Motion provided Workpeice. Material is removed in Forward Stroke and known as Cutting stroke

→ During return stroke No material is removed and hence It is known as idle stroke



* Feed is provided to Workpeice during idle Stroke of tool and feed is lateral (Side by side) [along breadth] and cutting is longitudinal

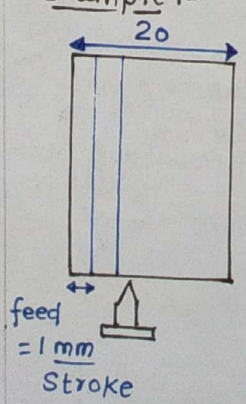


1 Forward Stroke + 1 Return stroke = 1 Complete stroke or one double stroke

Forward Stroke ↓ Cutting Stroke

Return stroke ↓ No material Removal [idle stroke]

Example :-



Time of shaping = No of stroke × $\frac{min}{Stroke}$

$$t_m = \frac{B}{f} \times \frac{1}{N}$$

$$\boxed{t_m = \frac{B}{fN}}$$

B = width of workpeice

fN = feed Velocity $\left(\frac{mm}{min}\right)$

$$\frac{mm}{Stroke} \times \frac{Stroke}{min} = \frac{mm}{min}$$

Time per stroke (min/stroke) $= t_f + t_r$

$= \frac{L_e}{V_f} + \frac{L_e}{V_r}$

$= \frac{L_e}{V_f} + \frac{\lambda L_e}{V_f}$

Note:- $V_f < V_r$

V_f = Forward Velocity

V_r = Return Velocity

$\lambda = \frac{V_f}{V_r} < 1$

but $V_f = V$

$$\frac{\text{min}}{\text{Stroke}} = \frac{L_e(1+\lambda)}{V \; 1000}$$

$$\boxed{\text{Stroke/min (N) or rpm of Crank} = \frac{V \times 1000}{L_e(1+\lambda)}} \quad \lambda < 1$$

λ = Ratio of Forward to return Speed $= \frac{V_f}{V_r}$

λ = Ratio of Return to Forward time $= \frac{t_r}{t_f}$ $\lambda < 1$

Note:- In whitworth QRMM (used in shaper) the Velocity of ram is maxm at Middle of Return stroke.

(2) Reciprocating motion of tool → Quick Return Mechanism

feed motion provided by workpeice → Paul and Ratchet Mechanism

Metal Removal Rate in shaping ⇒

$$\boxed{M.R.R = f d N L} \Rightarrow \frac{mm}{\cancel{Stroke}} \times mm \times \frac{\cancel{Stroke}}{min} \times mm = \frac{mm^3}{min}.$$

Note:- If Question given Specific energy $= 1.4\ J/mm^3$ and Asked Power

$$\boxed{\text{Power} = \text{Specific energy} \times M.R.R}$$

W/P → Small

Shaper

Tool Reciprocate (Cutting motion)

Workpeice feed

W/P large

Tool (feed) ← Planer

W/P reciprocates (Cutting motion)

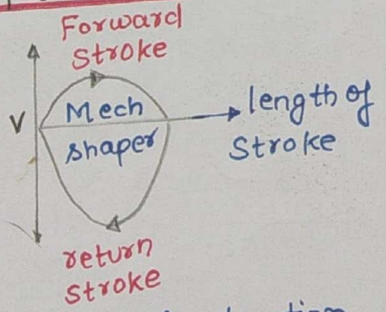
* It produce more accurate Surfaces

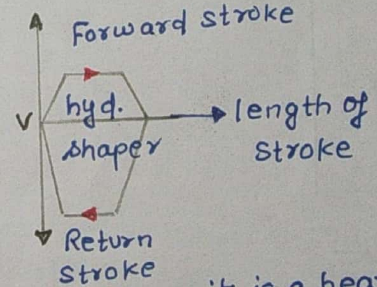
* planer is heavier, large and more rigid than shaper So They Can withstand heavy Vibration.

* More No of Cutting tool Used Simultaneously

Gate:- The Similarity b/w shaper and planner is that both are used to produce flat Surface

Comparison between Mechanical and hydraulic shaper





(1) Simple in Construction

(2) Speed of stroke will maxm at mid stage

(3) less No of stroke Covered at a given Cutting Speed

(1) Heavier and More rigid as it is a heavy System. As System is heavy due to heavy Oil tank [Supress large Vib]

(2) Speed ~~to~~ remain Constant throughout the stroke

(3) At a given Cutting Speed, more No of stroke Covered

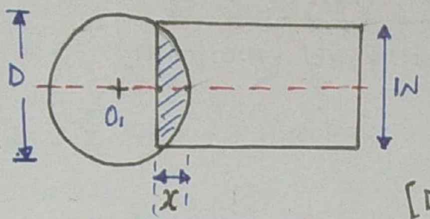
Note:- Vertical shaper are called slotter and it has Rotary worktable.

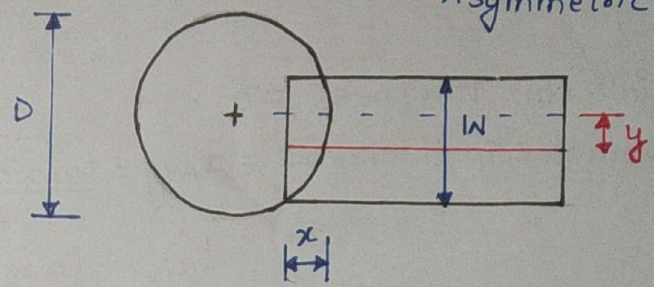
Milling

→ Milling is a machining operation in which material is removed by multipoint Cutter
→ The Cutter are Mounted on shaft are known as Arbor
→

Face milling [Vertical milling]

Symmetric — ASymmetric





$$\boxed{x_{sym} = \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right]}$$

$$\boxed{X_{ASYM} = \frac{1}{2}\left[D - \sqrt{D^2 - (W+2Y)^2}\right]}$$

Diameter is greater than width of workpeice.

$$\boxed{t_m = \frac{L_e}{f_m} = \frac{L_e}{f_t N Z} = \frac{l_w + l_a + l_o + x}{f_m}}$$

f_m → $\frac{mm}{min}$, f_t → $\frac{mm}{tooth}$, N → $\frac{rev}{min}$, Z → $\frac{tooth}{rev}$

$$\boxed{f_m = f_t N Z \quad \text{or} \quad F_t = \frac{F_m}{NZ}}$$

f_t = feed per tooth Z = No of teeth
N = R.P.M

Slot milling [End mill Cutter] :- Diameter of Cutter = Width of Slot

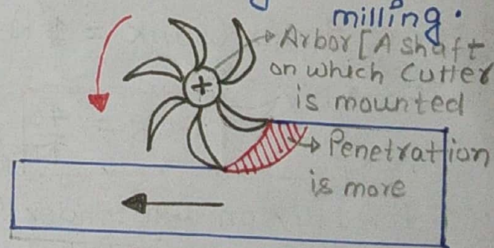
[D=W]

when D = W then $\boxed{x = \frac{D}{2}}$

Note :- कोई भी Question हो Milling का पहले x निकालेंगे

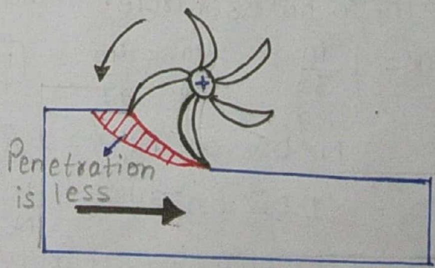
Peripheral mill Cutter → Horizontal milling (slab milling)
- → Upmilling or Conventional milling.
- → Down milling or climb milling.

(a) Upmilling or Conventional milling



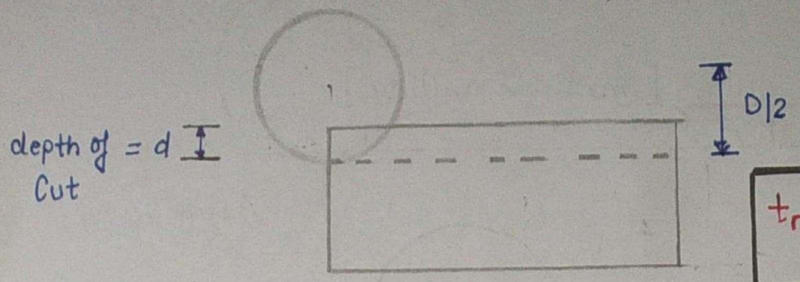
* Direction of Cutter and W/P will opposite to each other.
* Tool wear ↑ , Tool life ↓
  Surface finish ↓
* Cutter tends to lift the w/p so strong clamping is required
* chip thickness Varies minimum to maximum.

(b) Down milling or Climb milling



→ The direction of Cutter and W/P will be Same
→ Tool life ↑ , Tool wear ↓
  Surface finish ↑
→ Cutter tends to push the workpeice toward table, strong Clamping is not required
→ Chip thickness Varies maximum to Minimum.
→ In industry, generally down milling Used
→ Specific power Consumption is low.

Compulsory Approach for peripheral milling Cutter



$$\boxed{X = \sqrt{d(D-d)}}$$

Max^m chip thickness

$$\boxed{t_{max} = \frac{2f_m}{NZ}\sqrt{\frac{d}{D}}}$$

f_m = table feed (mm/min)

Min^m chip thickness = 0

Average chip thickness = $t_{Avg} = \frac{t_{max} + \cancel{t_{min}}^{\,0}}{2}$ If $t_{min} = 0$

$$t_{avg} = \frac{t_{max}}{2}$$

Indexing :- (a) Direct Indexing

Bevel Gear is Used
Gear Ratio = 24 : 1

24 Rev of Index Crank = 1 rev of W/P = 'N' division on workpeice

1 division = $\frac{24}{N}$ rev of Index Crank

For 1 Div

$$\boxed{ICR/Div = \frac{24}{N}}$$

If N = 10 $ICR = \frac{24}{10} = 2\frac{4\times 2}{10\times 2} = 2\frac{8}{20}$

~~For one division, Index Crank Rotates~~

For one division on Workpeice, Index Crank complete two full Revolution Followed by 8 hole movement in 20 hole Circular plate.

(b) Simple Indexing / Plane Indexing :- Worm gear is Used
Gear Ratio = 40 : 1

40 rev of Index Crank = 1 Rev of W/P = N Div on W/P

For 1 Div

$$\boxed{I.C.R = \frac{40}{N}}$$

Gate:- For 1 div on W/P, index Crank Complete 1 full rev followed by 10 holes in 30 holes Circle. Find the degree of rev for the workpeice.

Solu:- $ICR = 1\frac{10}{30} = \frac{40}{30} = \frac{40}{N}$ $\boxed{N = 30}$

N Div on W/P = 1 Rev of W/P

1 Div on W/P = $\frac{1}{N}$ Rev of W/P $= \frac{1}{30} \times 360 = 12^\circ$

Gate:- Using DI Mechanism, if a workpeice is to be divided into 8 equal division then For 1 Div, the degree of rev for Crank and W/P is

Solu:- N division on W/P = 24 rev of index Crank

1 div = $\frac{24}{8}$ = 3 rev of Index Crank = $3 \times 360 = 1080^\circ$

⇒ N division on W/P = 1 rev of W/P

1 div = $\frac{1}{8}$ rev of workpeice $= \frac{1}{8} \times 360 = 45^\circ$ rev of W/P

Type of Cutter (a) End Mill (b) peripheral mill
(c) Side mill (d) Form mill (e) Straddle mill → No of milling Cutter mounted on arbor is 2
→ They produce flat vertical surface on both side of W/P.
(f) Gang milling :- Two or more Cutter are Combined to remove material Simultaneously From a large W/P.

Grinding :- Grinding wheel में Tool, Abrassive होता है।
* Grinding wheel is balanced frequently to reduce Cutting time.
* It operates at highest Cutting speed
* It Consumes highest Specific power Consumption or highest Specific Cutting energy because wheel has multiple cutting edge with more of (-)ive rake angle then more force required at some point.

Specific Power Consumption [J/mm³] ⇒ $\boxed{C = \dfrac{Power}{M.R.R} = \dfrac{F_c V}{M.R.R} = \dfrac{F_c V}{bdV}}$

b = width (mm), d = depth of cut (mm)
v = Table feed (mm/min) F_c = Cutting Force (N), V = Cutting Speed = πDN $\frac{m}{min}$.

$\boxed{\text{If MRR} \downarrow \text{ then } C\uparrow \text{ or } , V\uparrow, C\uparrow}$

* Abrassive are Not Used in Burnishing process.

Reason For low M.R.R (a) Size effect (b) Welding effect (c) large (-)ive rake angle.

Turning	Grinding	Turning	Grinding
$(Power)_T$ =	$(Power)_G$	$(M.R.R)_T$ =	$(M.R.R)_G$
$C_T < C_G$		$C_T < C_G$	

$\uparrow C = \dfrac{Power}{MRR\downarrow}$ → same

$(M.R.R)_G$ is low due to Size effect

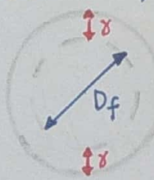
$\uparrow C = \dfrac{F_c V\uparrow}{M.R.R}$ → Same

Due to high Cutting Velocity

Mechanism of Grinding :- when Abrassive remove material then it is Subjected to wear. The worn out abrassive are pulled off the wheel by the rubbing Force b/w the wheel and the work when the outer layer are pulled out, the inner fresh layer get a chance for material removal, This is known as Self sharpening behaviour of Grinding wheel.

$$\boxed{G.R = \frac{V_m}{V_w} = \frac{\text{Volume of material removal}}{\text{Volume of wheel wear}}} = \frac{l \times b \times d}{\frac{\pi}{4} \times w \times [d_i^2 - d_f^2]}$$

$V_m = l \times b \times d$
$V_w = V_i - V_f = \frac{\pi}{4} D_i^2 w - \frac{\pi}{4} D_f^2 . w = \frac{\pi}{4} \times w [d_i^2 - d_f^2]$



wheel undergoes radial Wear
D_i = 200 mm
r = 40 µm
$D_f = D_i - 2r$
= 200 − .08
= 199.92

Grain/Mesh/Grit Size tell
↓
finish or Rough Grinding

Grinding wheel Specifications

[A]ttack [G]ate to [H]ave a [S]eat in [B]arc

A	G	H	S	B
Abrassive	Grain Size or Mesh Size, Grit Size	Hardness or Grade	Structure	Bond
↓ Alphabet	↓ Number	↓ Alphabet	↓ Number	↓ Alphabet

(1) ABRASSIVE

C
A
D

CBN/Carbides < SiC → Harder but it wear out quickly → Very hard W/P ; Hard W/P ↑ SiC [Non ferrous metal & alloy].
B₄C

Al_2O_3 → Soft & medium W/P [M.S, HCS, Brass, Bronze, H.S.S] → ferrous material. [It has high chemical Inertness toward cutting fluid and it is tougher than Silicon Carbide. tougher & shock resistance]

Diamond → Hard

Ques:- why diamond is not Used for grinding steel ?
Solu:- Due to diffusion of Carbon atoms in steel, machinability of steel decreases.

In term of Hardness [Diamond > CBN > SiC > Al_2O_3]

* Silicon Carbide is Natural Abrassive material while Al_2O_3, CBN are Synthetic material

(10)

Abrassive material		Trade Name
Silicon Carbide [SiC]	→	Carborundam & Crystolon
Al_2O_3	→	Aloxite, Alundum and Borolon
CBN	→	Borazon

② Grain Size or Girt Size

G.S.N (Grain Size No)	G.S	
10 – 24	Coarse	Rough Grinding
30 – 60	Medium	Rough Grinding
80 – 180	fine	Finish Grinding
220 – 600	Very fine	Finish Grinding

$$\text{Grain Size} = \frac{1}{G.S.N}\ \text{inch} = \frac{1}{G.S.N} \times 25.4\,mm$$

* when material is removal in Bulk, Coarse grain is used and this is Called Roughing operation

* In Case of Finishing & Super finishing operation Fine grain structure is Used at high Speed.

1 inch = 25.4 mm

Example A (27) K 12 V

Abrassive (Al_2O_3) ⇒ Grain Size $= \frac{1}{27} \times 25.4\,mm = 0.9\,mm$

* Hardness or Grade :- The ability of bond to retain its Abrassives

A – H → Soft wheel – Hard W/P.
I - P → Medium wheel – Medium Workpeice.
Q - Z → Hard wheel – Soft Workpeice.

Case:- 1 Hard W/P and Hard wheel :- If the w/P is hard, rubbing Force will be high and abrassive will wear out quickly but since the wheel is also hard it won't allow the abrassive to be pulled off. Thus worn out abrassive will rub on the workpeice and no material will be removed, more over fresh layer of abrassive will Not get a chance of machining. This is known as Glazing or Blunt wheel grinding. After glazing is observed a Single point turning tool Can be Used to remove the worn out abrassive Forcefully From the grinding wheel. This process is known as Dressing.

Tool life of grinding wheel is defined as The time period b/w two Successive wheel dressing.

Structure < OPEN / DENSE — It refers to the Average gap b/w two Consecutive abrassive.

Structure Number ∝ Average gap.

SN - [0 - 7] Dense [Finish grinding]
⇓
Dense structure ⇒ For Finish grinding & Hard W/P

SN [8 - 16] Open [Rough grinding]

Open Structure ⇒ For rough grinding & Soft workpeice.

$$\text{Average gap b/w Abrassive} = \frac{\text{Structure No}}{1000}\ \text{inches}.$$

* If Rough grinding is performed using dense structure chips will Not Find enough Space to flow out and chips will be clogged within the interspaces of abrassive. This is known as loading of grinding wheel.

Other Reason of loading
* If the w/P is too Soft
* If r.p.m of grinding wheel is low
* If Cutting fluid is not properly Supplied

A Soft material Cannot be economically grinded due to production of long Continuous Chips in case of Soft material, Continuous chips Forced to enter into the Spaces between the abrassive grain and leads to Frequent clogging of wheel.

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BOND :- V-BOND – Vitrified Bond → Latin word "Vittreum" [glass like]

[clay + feldspar] $\xrightarrow{\text{Cooled}}$ Hard glass like bond → Vitrified Bond (11)

Binder ↓ Δ 1250°C

This process is known as Vitrification. V ~ 2500 m/min

* V Bond is Not Used for high Speed grinding because it has hard & brittle and under the influence of of high Centrifugal Force, the bond may break. It has highly reliable for slow and medium Speed grinding
* high thermally stable and chemically inert toward Cutting fluid.

(b) Rubber Bond :- Used for Soft wheel [Used for polishing & Centreless grinding]

(c) Sodium Silicate :- $NaSiO_3$ It Used as a bonding material For grinding wheel.

*It is known as Water glass

* It is Used for medium & high Speed grinding wheel.

"Creep" feed Grinding (Single pass Grinding)

In this process, the table feed will be extremely slow and the depth of Cut will be high Such the grinding involves one pass only

Truing :- It is a process of bringing the grinding wheel from an outshaped Form into proper roundness and Circularity by the help of Single point turning tool.

Centreless Grinding :-

* Direction of Workpeice is opposite to all other wheels [Guiding or Regulating wheel or grinding wheel]
* There will be No Fixed centre provided to W/P
* It is generally Used for Solid or hollow Cylindrical Specimen
* In Centreless grinding, the W/P Centre above the line Joining the two wheel Centre.

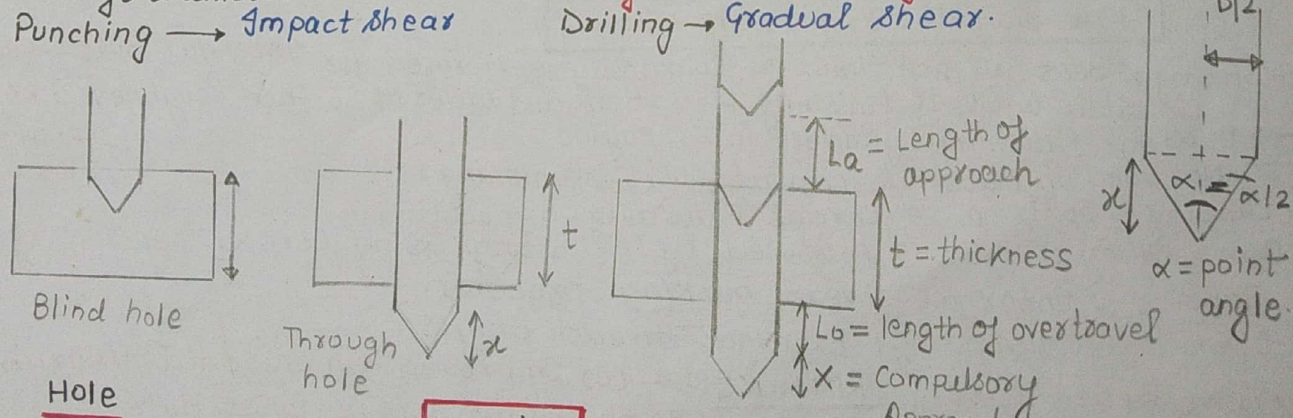
$\boxed{F = \pi D N \sin\alpha}$ D = Regulating wheel dia, N = Speed of Regulating wheel.

* Solid Cylinder ⇒ External C·G ⇒ R·W < G·W
* hollow Cylinder ⇒ internal C·G ⇒ R·W > G·W

Drilling :- It is Machining process in which holes are produced Such that both Cutting motion and feed motion Can be provided to the tool.

For large diameter holes :- BTA [Boring tool & trepanning] & Gun drill

Punching → Impact shear Drilling → Gradual shear.



Hole → Blind (L < t), Through (L > t)

$\boxed{t_m = \frac{L_e}{fN}}$ mm/rev, rev/min

If α = Not given

$\boxed{\begin{array}{l}\text{Blind hole} = x = 0.3D \\ \text{Through hole} = x = 0.5D\end{array}}$

$\boxed{L_e = t + l_a + l_o + x}$

* If point ∠ is given then We always find Compulsory Approach (x) → $\boxed{x = \frac{D/2}{\tan\left(\frac{\alpha}{2}\right)}}$

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

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Note:- Double fluted Drill का मतलब है जो f_t की value है। उससे दो का Multiply कर दो

For exp:- F_t = Feed per tooth = 0.2mm

feed per flute mean 1 rev = 2 flutes

feed per rev = 0.4 mm/rev

(a) No of holes produced $= \frac{T}{T_m}$ or No of part produced

No of tool change required $= \frac{t_m}{T}$

(c) Production time per hole $= \frac{\text{Total time}}{\text{Total hole}}$

T = tool life

T_m = Machining Time

Note:- If in Question, given that

(1) Neglect Approach and overtravel $L_e = t$

Approach and overtravel is equal to radius of drill $L_e = t + 0.5D$

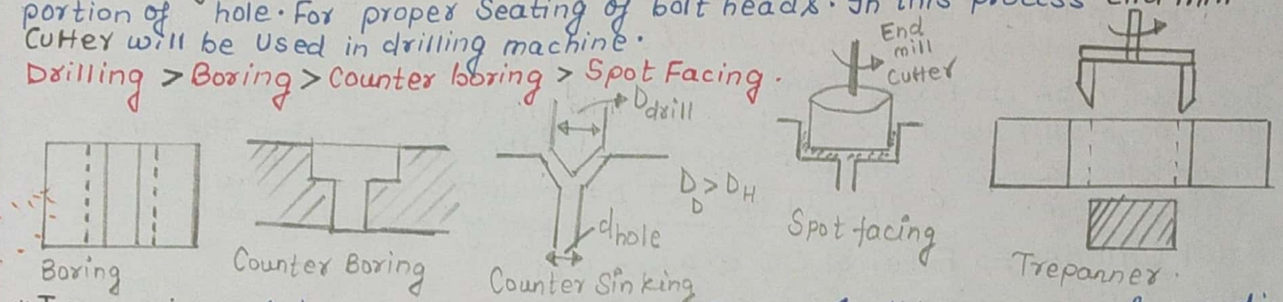
Other Machining Operations

* Boring :- Hole enlargement process
* Counter Boring :- enlargement upto Certain depth to accomodate bolt heads
* Counter Sinking :- making a Conical enlargement at one end of hole. OR It is a machining process that make a Cone shaped recess at the top of hole to accomodate Screw head.

$\boxed{\text{Major dia of hole} \le \text{Major dia of tool}}$

* Spot facing :- In this process Internal chips will be removed From the ~~en~~ enlarged portion of hole. For proper Seating of bolt heads. In this process end mill Cutter will be Used in drilling machine.

Drilling > Boring > Counter boring > Spot Facing.



* Trepanning :- A trepanning tool Used in lathe, In this process a large dia holes are produced without drilling and First used in Post-Mortem operation
  * trepanning is done for through hole only
* In trepanning the entire material is not converted into chips

$\boxed{\text{Large dia hole} = \text{Trepanning} + \text{Boring}}$

* Honning :- Best Surface finish or Commonly performed for Internal Surfaces. It is a Super finishing operation and Order of Surface Roughness = .01 μm = .01 micron
  → Used for finishing Cylinder in I.C engine
  → Not Used in material removal (only for finishing)
* Lapping :- It is a external Finishing operation.
* Core drilling :- Holes is produced by Casting using Cores.
* Tapping :- Internal thread making process.
* Open die threading :- External thread only.

REAMING

(a) Give Best Accuracy

(b) Sizing and Finishing a hole

(c) Improved dimensional tolerance

(d) It require a pre-exist hole.

Reamers does not produce hole it Can enlarge and Finishing a hole

[For hard W/P]

Right hand helix [$\psi \neq 0$]
* pull chips toward back of reamer or shank
* Sizing a blind hole
* Used For hard & strong w/p.

Left hand helix
* push the chip toward the tip of reamer
* Machining through hole
* Use for Soft and ductile workpeice

Straight fluted [$\psi = 0$]
* Rake angle is Zero
* fluted are ∥ to axis
* No chip lifting Capacity
* chip will fall under the action of gravity
* Used for through holes machining

* Reamer are having even Number of flutes to reduce the Cutting Forces. 13

Note:- Hard W/P, through hole maching which reamer will be Used as helix angle ↑ → Strength ↓ ∵ If helix angle = 0, Strength is more So straight fluted reamer will be Used.

* Inverted drilling Machine :- In this process, high feed and heavy depth of cut is provided, Generally Used for deep hole drilling and it is also known as Oil hole drill.

* Radial drilling Machine

V = N × 1P → Single start

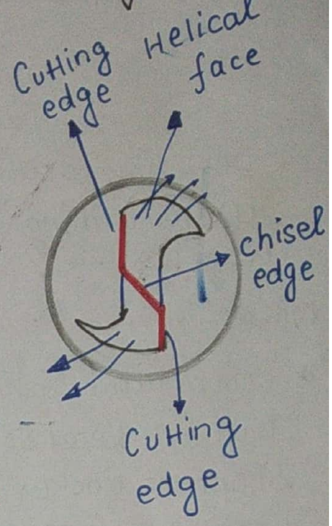
V = N × 2P → Double start

$V \Rightarrow \frac{rev}{min} \times \frac{mm}{rev} = \frac{mm}{min}$

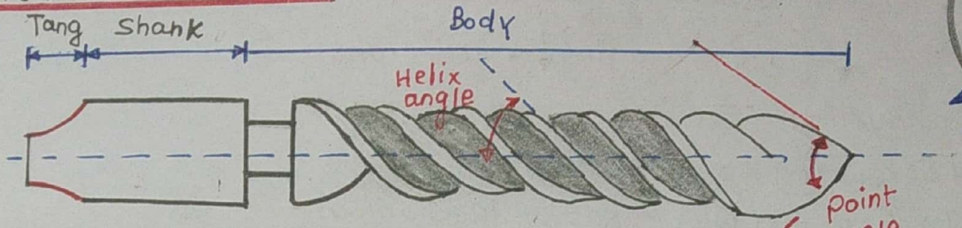
N = r.p.m of Lead Screw

P = pitch of lead Screw

V = Vertical Speed of radial Arm.



Twist Drill Geometry



Note:- Why we provide helix (or) Flute.

→ Chips lifting Capacity

→ To provide Variable rake angle

* To break the chips

* To enable the Cutting fluid to reach the Cutting edge.

Note:- The Cutting portion of drill is to be welded to its shank, The best suited process is Friction welding.

→ Rake ∠ is less → strength is more

Rake ∠ is more → Ease in chip flow

* Rake angle is minimum at dead center ~~and~~ to impart more strength to drill and Rake angle is maximum at outermost periphery to keep the chip flow better and becomes equal to helix angle.

$$\boxed{\begin{array}{l} \text{Max}^m \text{ rake angle} = \text{Helix Angle} \\ \text{Rake angle} \le \text{Helix Angle} \end{array}}$$

$$\boxed{\text{Helix Angle} \propto \text{Rake Angle} \propto \frac{1}{\text{Point Angle}}}$$

Soft and ductile W/P ⇒ Point Angle ↓

Rake Angle ↑

helix Angle ↑ [b/w 34°-38°] known as fast helix drill [high helix rate

chip lifting capacity high, low drill strength

Hard & strong W/P ⇒ Point Angle ↑

Rake Angle ↓

helix Angle ↓ [b/w 12-22°] know as slow helix drill

⇒ less helix rate, chip lifting capacity will be poor due to slow helix rate, Drill strength is high and Used For deep holes

Regular helix drill ⇒ $\psi = 24° - 32°$

It is Used for medium W/P → Brass, Bronze

Point Angle:- HCS → 120°
Carbides → 135-150°
Mild steel → 118°

Cast Iron = 116° [Anamolous behaviour]
Wood = 60° - 80°

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* Shank is of two types :-

(1) Straight [3-Jaw chuck]
D < 12.5 mm
For small hole diameter

(2) Tapered (Self locking tendency)
D > 12.5
General purpose

Chip lifting ⟶ S < R < F
Drill strength ⟶ F < R < S

R = regular
S = slow
F = Fast

* Deep hole drilling
(1) Gun drilling ⟶ 3mm ≤ Drill ≤ 50mm
(2) BTA ⟶ 15mm ≤ Drill ≤ 600mm

BTA ⇒ Boring and Trepanning

Note:- Thrust Force ↓ [Point Angle ↓, helix angle ↑]

* Centre lathe :- knurling
Lathe :- Lead Screw or Apron Mechanism
Shaper :- Rocker Arm or Quick Return Mechanism
Enrager :- Pantograph Mech. Press :- Toggle Mechanism
Automobile :- Ackermann Mech.
Drilling M/c :- flute or Counter Boring
Milling M/c :- Universal indexing or Indexing Mech. or slotting
Centreless Grinding :- Regulating Mech.
Grinding :- Dressing.

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