Milling Machines

- Milling machines are the most widely used for manufacturing applications
- In milling the workpiece is fed into a rotating milling cutter which is multipoint tool as shown in the below figure
- The milling process is characterized by:

  1- Interrupted cutting

  2- Small size of chips

  3- Variation in chip thickness

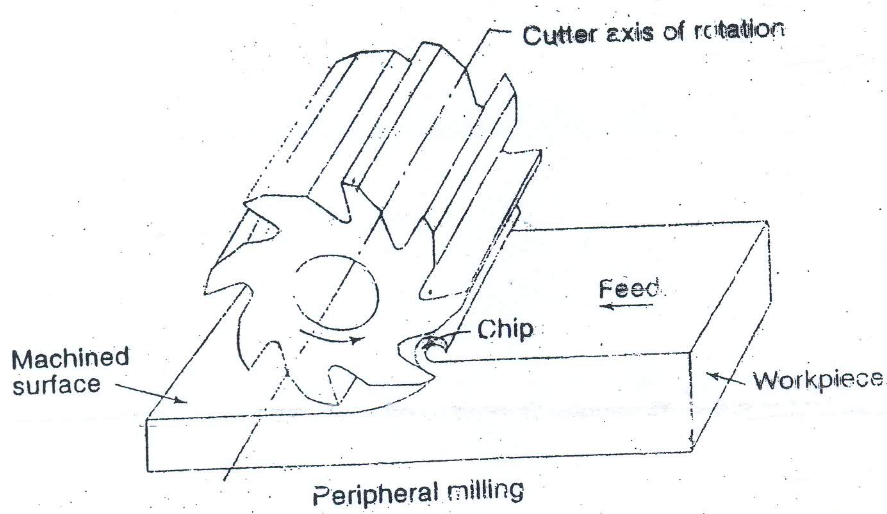


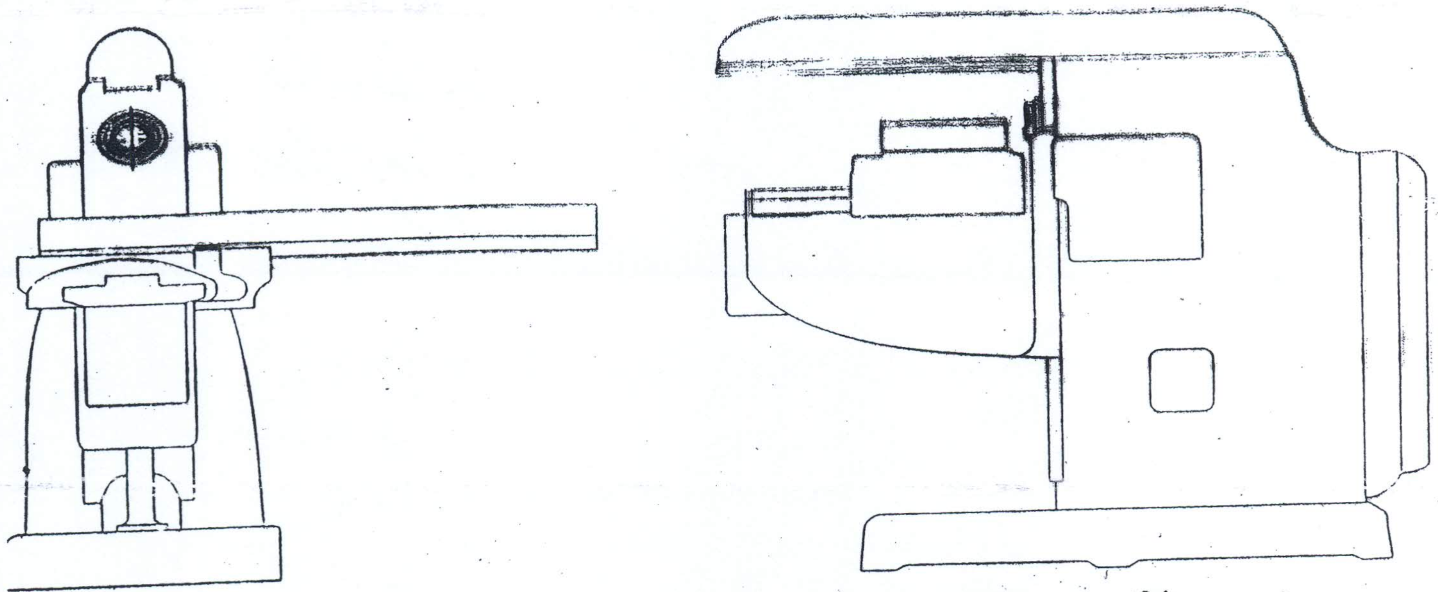
diagram of a milling operation

Types of Milling Machines

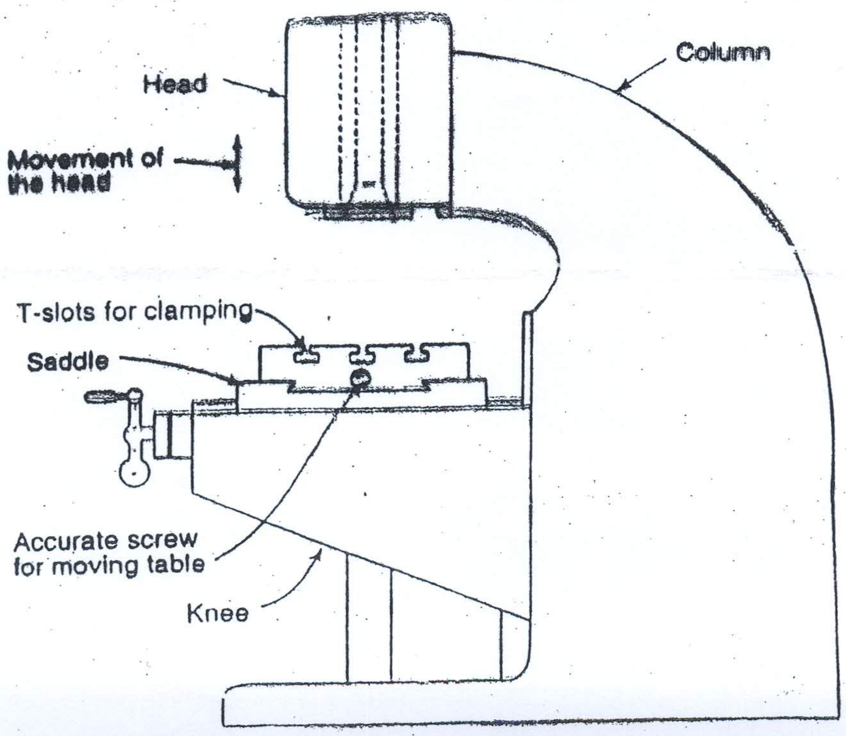
1- Horizontal Milling Machine

2- Vertical Milling Machine

3- Universal Milling Machines

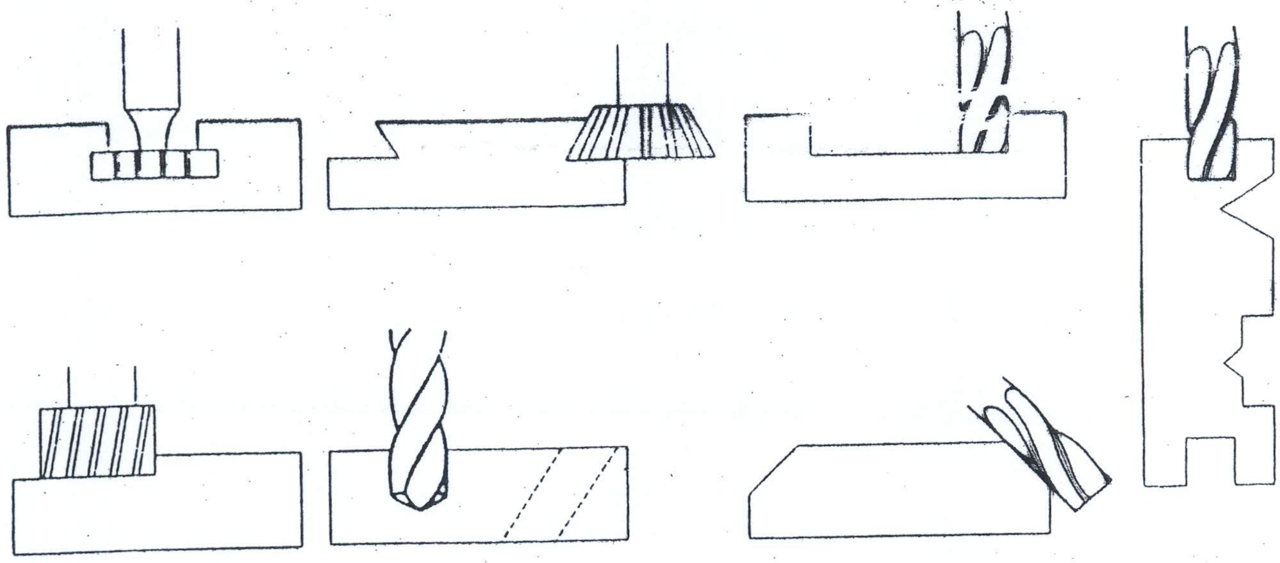


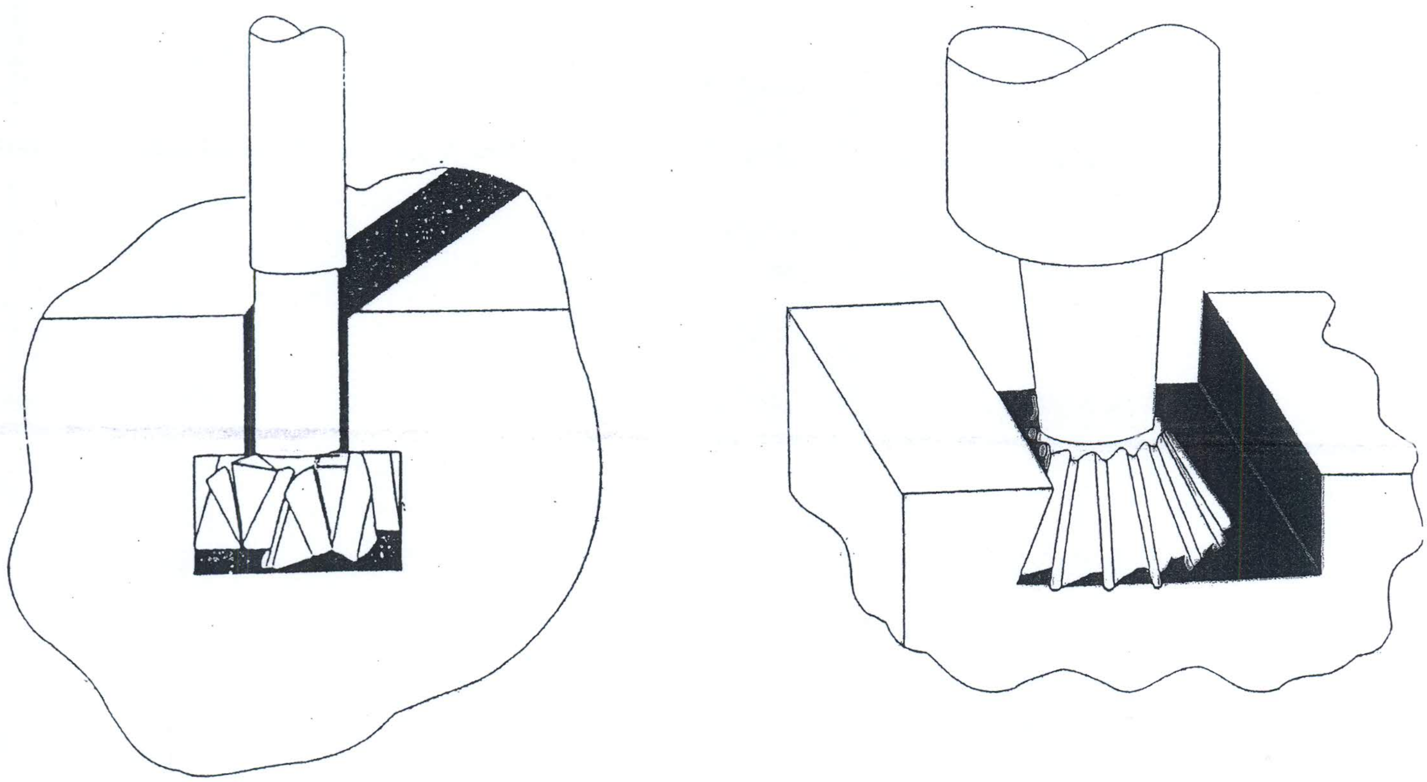
Horizontal knee and column type milling machine



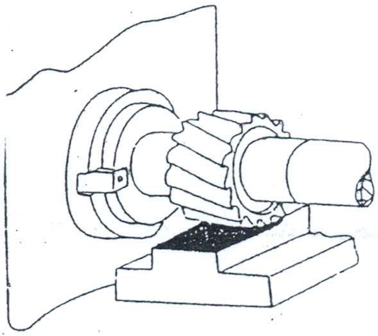
Vertical knee and column type milling machine

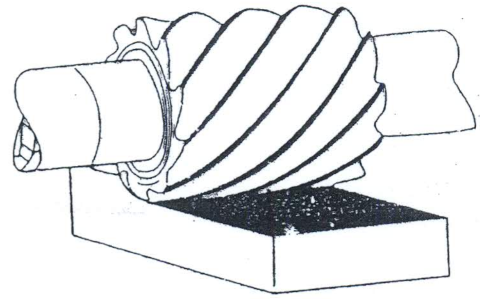
Some of milling operations normally carried-out vertical axis machines

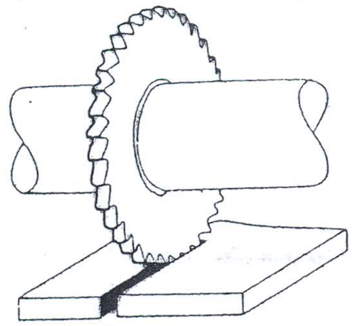


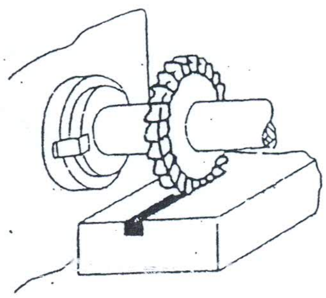


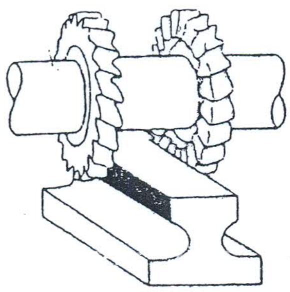
Some of milling operations normally carried-out horizontal axis machines

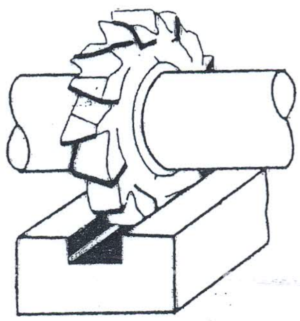

(a) Slab milling cutter

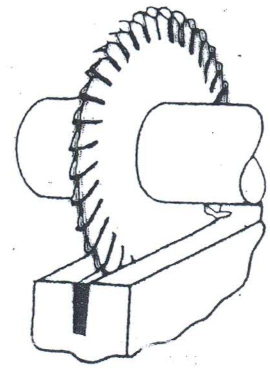

(b) Slab milling cutter

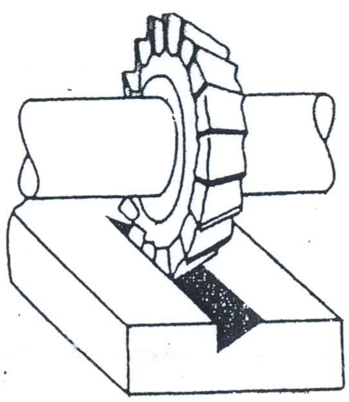

(c) Slitting saw

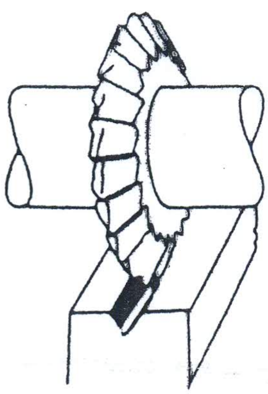

(d) Side and face cutter

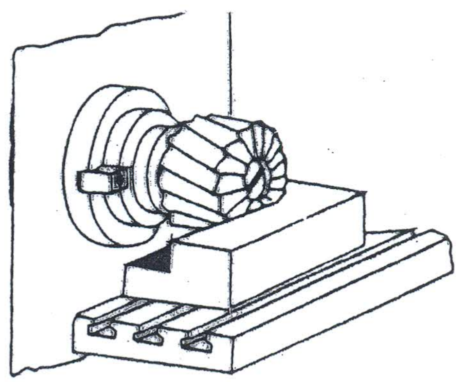

(e) Two side and face cutter

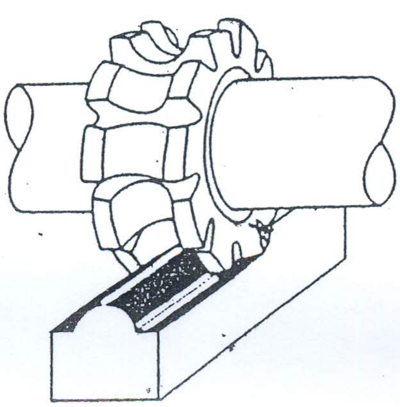

(f) Staggered tooth cutter

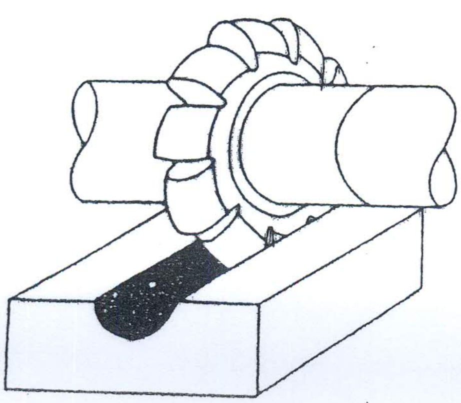

(g) Side and face cutter

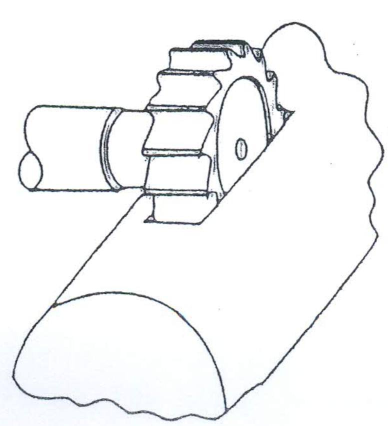

(a) Angle milling cutter


(b) Angle milling cutter


(c) Shell end mill


(d) Form relieved circular cutter


(e) Form relieved circular cutter


(f) Woodruff key cutter

Types of Milling Cutters

1- Based on construction:

a- Solid

b- Inserted tooth type

2- Based on mounting :

a- Arbor mounted

b- Shank mounted

c- Nose mounted

3- Based on rotation:

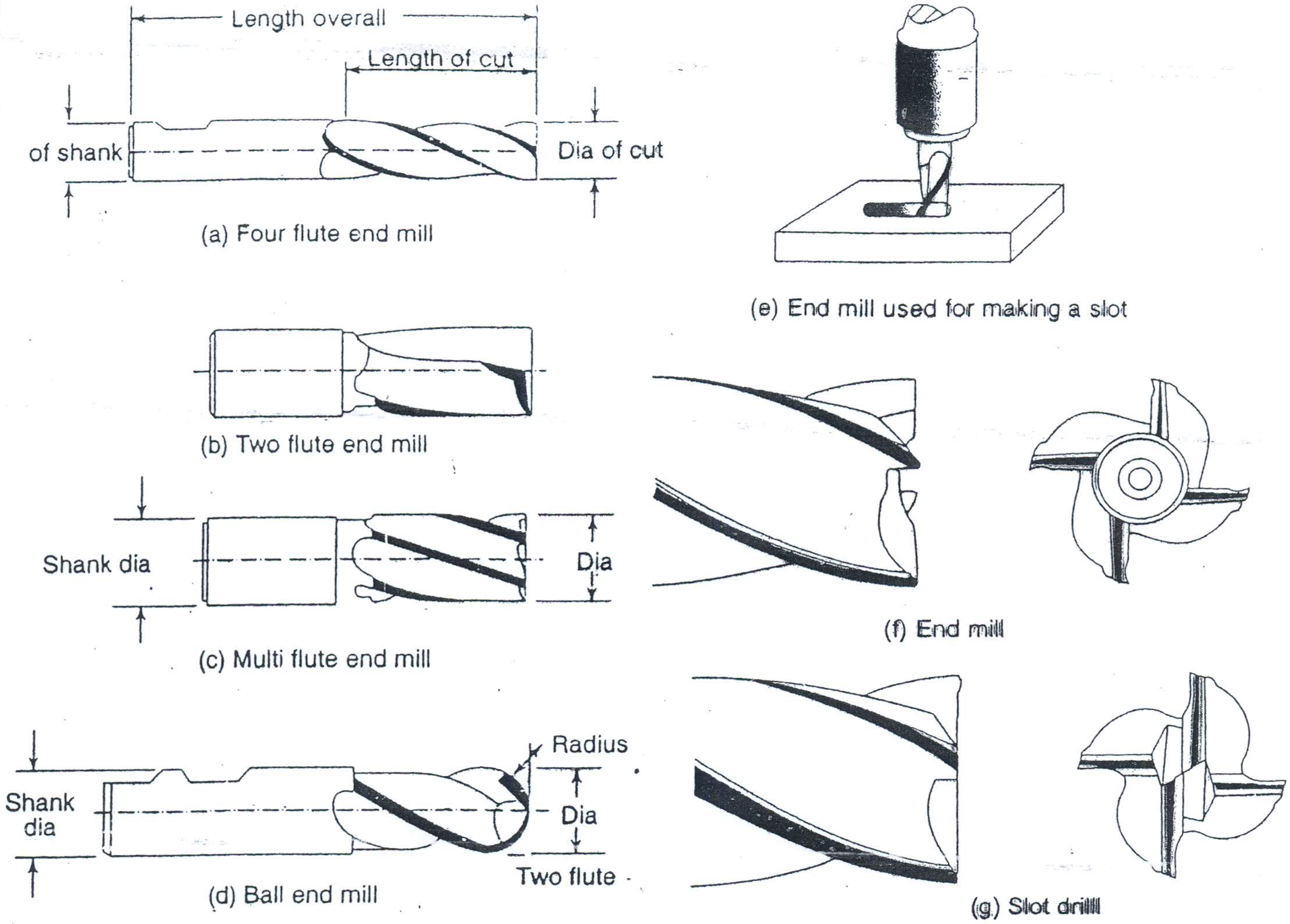
a- Right hand rotation

b- Left hand rotation

4- Based on helix:

a- Right hand helix

b- Left hand helix



Shank mounted milling cutters and various types of end mills

NEW

in this catalogue

Milling

CoroMill® 490

New generation face and shoulder milling cutter gives high precision production economy in steel and cast iron. See page D50

CoroMill® 690

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Grade GC1030

PVD coated steel milling grade for high cost efficiency, ideal for end milling, unstable conditions and small cutters.

Grade GC4240

The secure option for shoulder milling and steel milling in all CoroMill concepts - first choice for CoroMill 390.

Grade GC4230

For steel milling and all-round productivity – an optimizer to GC4240.

Grade GC1010

High edge line toughness and wear resistance, for roughing to finishing of hardened steels.

CoroMill 327 and 328

Grooving programme extension - new insert styles in grade GC1025 for all materials. See page D105

CoroMill Plura

Kordell grade GC1640, for reliability in toughness demanding roughing operations - to 48 Hrc. See page D117

CoroMill 365

Wiper inserts give high productivity and complete the CoroMill 365 assortment. See page D30

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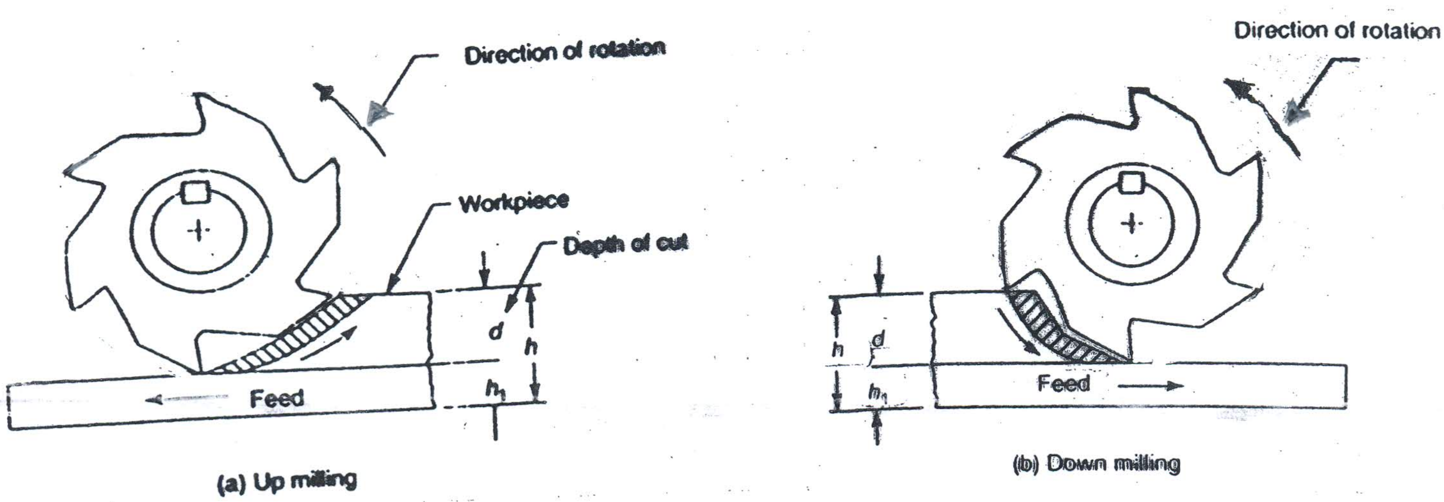
Up Milling (Conventional Milling)

- The cutting tool rotates in the opposite direction to the table movement.
- The chips starts as zero thickness and gradually increase to the maximum

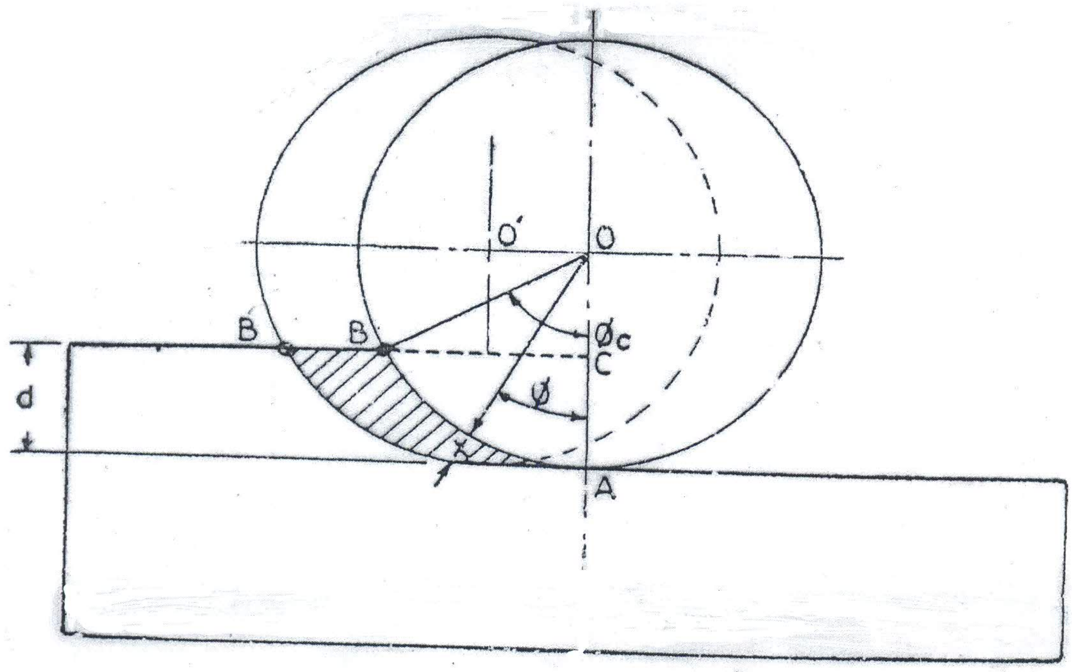
Down Milling (Climb Milling)

- The cutting tool rotates in the same direction as that of the table movement
- The chips starts as maximum thickness to zero



Up milling and down milling

Slab Milling (Plain Milling)



The cross section of the chip produced by a single tooth during milling will be the one confined within two arcs of a radius equal one half milling cutter diameter

$OC = (D/2 - d)$, $OB = D/2$

$BC = \sqrt{D^2/4 - (D/2 - d)^2} = \sqrt{d(D-d)}$

The tooth contact angle ϕ_c

$\cos \phi_c = (D - 2d)/D$

Chip thickness for any contact angle (ϕ)

$x = f_t \sin \phi$ (where f_t feed per teeth)

$(x) \cdots\cdots\rightarrow (x)$ Maximum

$(\phi) \cdots\cdots\rightarrow (\phi_c)$

(x) Maximum $= f_t \sin \phi_c$

But $f_t = f/ N^*n_t$ Where: n_t = number teeth, N = rpm

And $\sin \phi_c = (2/D)\sqrt{d(D-d)}$

(x) Maximum $= 2^*f/ (N^*n_t^*D) \sqrt{d(D-d)}$

If W = width of workpiece =

$A_{max} = 2^*f^*w/ (N^*n_t^*D) \sqrt{d(D-d)}$

$A_{mean} = (A_{max} + A_{min}) = A_{max}/2$

Peripheral component of cutting force (F)

$F = \sigma * A_{mean}$

Where (σ) = specific cutting pressure (get it from table)

Cutting Horse Power = (P) = F*V/(75*60) HP

Feed $= f_m = f_t^*N^*n_t$

Material Removal Rate= MRR= L^*W^*d/ T_m

$T_m = (L + L_a + L_O) / f_m$

Example

Determine the power required for the following slab milling operation

- Work material .... soft steel
- Cutter diameter(D)...........................75mm
- No of teeth(n_t)............................. 8
- Cutting speed (V) ....25 meter / min
- Feed (f)...75 mm/min
- Width of cut (W) ....100 mm
- Depth of cut (d) .... 5 mm

Solution: The maximum chip thickness

(x) Maximum = $2*f/ (N*n_t*D) \sqrt{d(D-d)}$

N = V*1000/π*D = 25*1000/π*75 =106 RPM

(X) maximum= $(2*75/106*8*75) * \sqrt{5(75-5)}$ = 0.0442 mm

FORCE= $\sigma * A_{mean}$ where (σ = 300 kg /mm^2 from table)

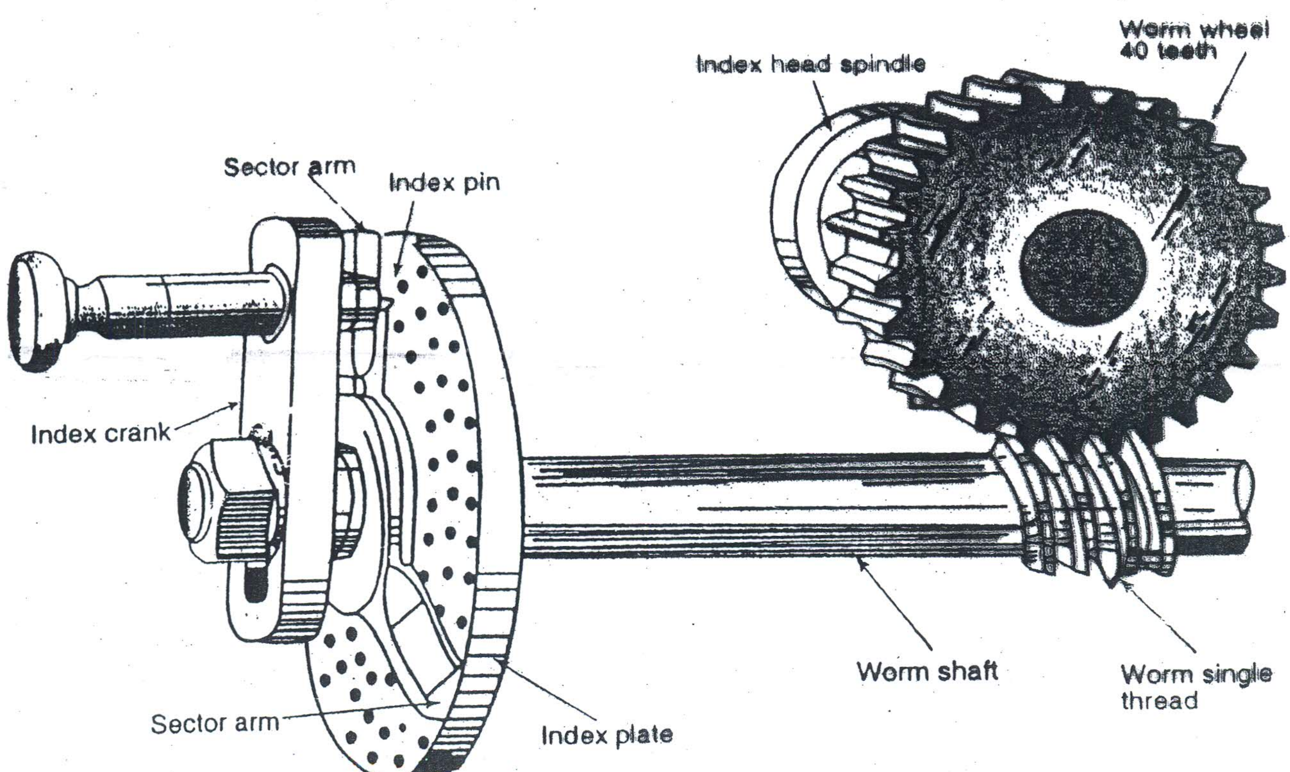
A_{mean}= 0.442*100/2 = 2.21 mm^2

Force = 300*2.21 = 663 kg

POWER (HP)= F* V/ 75*60 = 663 *25/75*60 = 3.68 HP

Dividing Head

- A dividing head is one of the most important attachments of the milling machine
- The main spindle of the dividing head drives the workpiece by means of a 3-taw chuck or a dog and live center similar to a lathe
- The index plate of a dividing head consists of a number of holes with crank and pin
- The index crank drives the spindle and live center through a worm gear, which generally has 40 teeth
- As a result, a full rotation of the workpiece is produced by 40 full revolutions of the index crank



Indexing method of a dividing head

<u>The index plates available are:</u>

<u>Plate # 1:</u> 15, 16, 17, 18, 19, 20 holes

<u>Plate # 2:</u> 21, 23, 27, 29, 31, 33 holes

<u>Plate # 3:</u> 37, 39, 41, 43, 47, 49 holes

<u>The different types of indexing</u>

- Simple indexing
- Compound indexing
- Differential indexing

<u>Simple indexing</u>

Simple indexing is the name given to the index method which is carried out using any of the indexing plates in conjunction with the worm.

With this it is possible to obtain relatively simple divisions

By simple indexing we can work any teeth of gear from:

<u># 1 to # 50</u> and even number <u># 52 to # 100</u> except *# 96*

Example: # 1

Indexing 28 divisions

Solution:

Number of turns of crank = 40/28= 1 3/7 turns

This can be done as follows using:

*One full rotation+ 9 holes in a 21 hole circle in plate #2

*One full rotation + 21 holes in a 49 hole circle in plate #3

Example: # 2

Indexing 62 divisions

Solution

The rotation of index crank = 40/62= 20/31 turns

This can be done as follows using the plate #2

20 holes in a 31 hole circle in plate #2