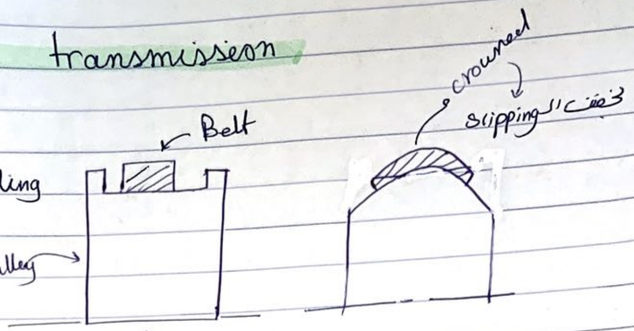
Ch 17

Flexible Power transmission

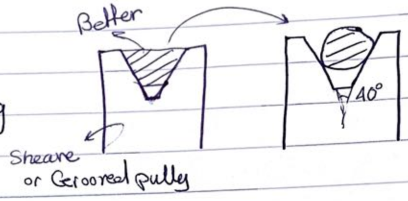
Belts

- Flat belt → pulling
  There is slipping



- Round } with sheave
- V-Belt } less slipping

High friction ← V-Belt



- Timing
  (such as one in the sprocket vehicles)

jo

▸ Belt drive

1- open Belt drive

$$\gamma = \sin^{-1}\left(\frac{D-d}{2c}\right)$$

طول الـ Belt

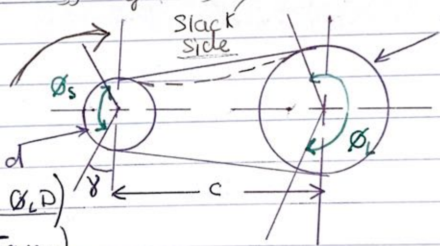
$$L = \sqrt{4C^2 - (D-d)^2} + \left(\frac{\theta_s d + \theta_L D}{2}\right)$$

(if in degrees) $\pi \to 180°$

Angle of contact:

$$\theta_s = \pi - 2\sin^{-1}\left(\frac{D-d}{2C}\right)$$

$$\theta_L = \pi + 2\sin^{-1}\left(\frac{D-d}{2C}\right)$$



Power drive is dependent on θ_s

Slack side must be on Top

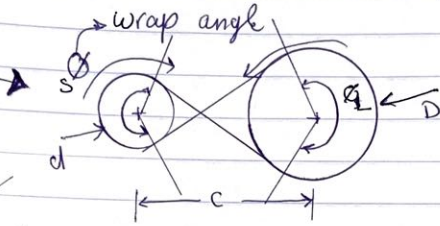
θ_s : wrap angle : Power transmitted by θ_s which is more critical when the pulleys are closely spaced and high difference in size

Note: Flat and Round : L as much as u want
V belt : has limited / standard L

Example

Cross Belt

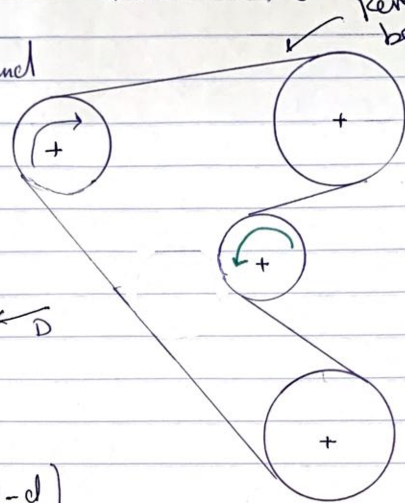
- only for flat and Round



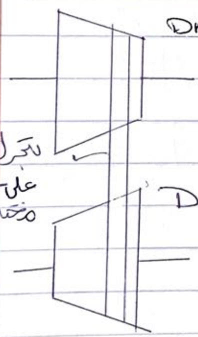
$$\phi_s = \phi_L = \pi + 2\sin^{-1}\left(\frac{D-d}{2C}\right)$$

$$L = \sqrt{4C^2-(D+d)^2} + \phi\left(\frac{D+d}{2}\right)$$

2- Reversing drive

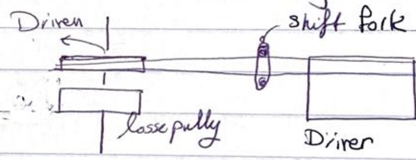


Variable drive belt



بتحرك فبنحصل على سرعات مختلفة

3- Clutching Action



Flat belt (and Round): material used: leather (جلد حيواني), urethane, Polymid from Table [17-2]

* Flat and round belts must be installed with initial tension [Fi] : $T=0$ (Torque) $\Rightarrow F_1 = F_2 = F_i$

بنشده قبل ما أشغل

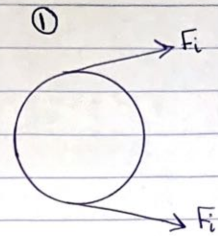
$T > 0$. $F_1 \uparrow$, $F_2 \downarrow$

$F_1 = F_i + \Delta F$

$F_2 = F_i - \Delta F$

$T = (F_1 - F_2) r$

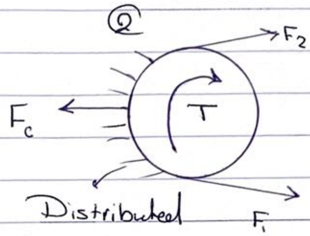
F_c: centrifugal force



Taking F_c into consideration

$F_1 = F_i + \Delta F + F_c$

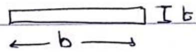
$F_2 = F_i - \Delta F + F_c$



$F_c = m r^2 \omega^2 = m v^2$

mass/Length ⇒ Specific weight (γ) from table

Important → $W = \gamma b t$ (N/m) → $m = \dfrac{W}{9.81}$ or 32.2



if english we need W to be $\frac{lb}{ft}$

So $W = 12 \gamma b t \left(\frac{lb}{ft}\right)$

and $F_c = m\left(\frac{V}{60}\right)^2$ Since V is in ft/min

Important

$T = (F_1 - F_2)\dfrac{D}{2}$

$= 2\Delta F \dfrac{D}{2}$

With or without centrifugal force

So $\boxed{\Delta F = \dfrac{T}{D}}$ --- ①

Also $\boxed{\dfrac{F_1}{F_2} = e^{f\phi_s}}$ (neglecting F_c)

(f → friction, Table 17-2)

$\boxed{\dfrac{F_1 - F_c}{F_2 - F_c} = e^{f\phi_s}}$ --- ② (including F_c)

or you can use: $F_i = \dfrac{F_1 + F_2}{2} - F_c$

$F_i = \dfrac{T}{D}\,\dfrac{e^{f\phi} + 1}{e^{f\phi} - 1}$ — ①

$F_1 = F_i + F_c + \dfrac{T}{D}$ ②, $F_2 = F_i + F_c - \dfrac{T}{D}$ ③

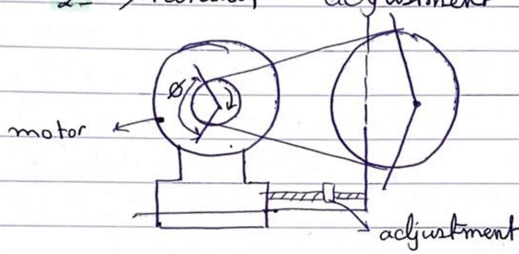
II. How to assure Belt initial tension F_i

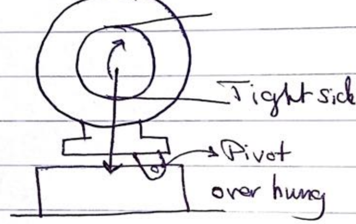
$F_i = \frac{F_1 + F_2}{2}$: satisfactory initial tension

It is lost with time → belt slightly stretching

1- Install belt with excessive initial tension (over load bearing and shaft shorten the life of belt)

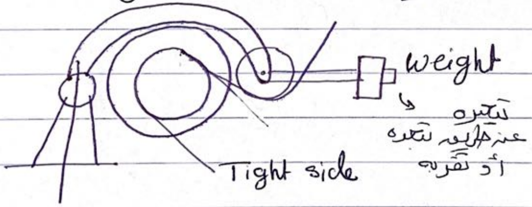
2- Manual adjustment





3- Pivoted, overhung motor

4- weighted idler pulley



Power transmitted

- limited by F_{all} of belt

← $F_{all} = \frac{lb}{in}$ at $V = 600$ fpm (Taken from Table 17-2)

This is F_1 since $F_1 > F_2$

$(F_{1all}) = C_V \, C_P \, [F_{all} \, b]$ ← lb

عرض (width) ↑ ; C_P ↳ pulley diameter correction

C_V : velocity correction factor
Urethane, polymide → $C_V = 1$
leather → Fig [17-9]

numbers are thickness taken from table 17-2

C_P : pulley size correction factor
less Bending at higher d of pulley
higher " " less d " "

larger Pulley C_P ↑, better

* taken from table [17-4] (used for leather and Polymide)
for urethane = 1

$H_{nom} = (F_1 - F_2) V = Tw$ (Watts)

$= \frac{(F_1 - F_2) V}{33000}$ hp

$= \frac{T n}{63025}$

$\frac{D}{d} = V_r$

$H_{all} = H_{nom} \, n \, K_s$

n : factor of safety ; K_s ↳ service factor

$H_{nom} = \frac{(F_{1al} - F_2) V}{33000 \, K_s \, n} = \frac{H_a}{K_s \, n}$

K_s from Table [17-15]

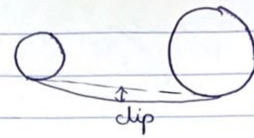
Dip

$w = \gamma b t$ N/m (γ from table)

$w = 12 \gamma b t$ lb/ft

$dip = \frac{12}{8} \frac{w c^2}{F_i}$ ft (w → weight/with)

$dip = \frac{w c^2}{F_i (8)}$ m



Check of Slipping

$$\frac{F_{1a} - F_c}{F_2 - F_c} = e^{f'\phi}$$

$$f' = \frac{1}{\theta_s} \ln \frac{F_{1a} - F_c}{F_2 - F_c}$$

If $f' > f$ → Slipping

$f' \leq f$ → No Slipping

Readjustement of Belts:-

1_ Pivoted motor (overhung)

2- Manual Adjustement

3_ Idler pully

For V Belt.

- standard sizes: A, B, C, D, E : Table 17-9
- works well for short distances
- Does not require frequent adjustment

V- Belt selection

1- cross section Area

→

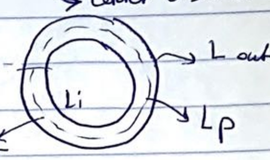
2- Pitch length

↳ depends on Diameters chosen

$$L_p = L_{in} + \Delta L = 2C + \pi \left(\frac{d+D}{2}\right) + \frac{(D-d)^2}{4C}$$

C → center distance

$$C = \frac{1}{4}\left\{\left[L_p - \frac{\pi}{2}(D+d)\right] + \sqrt{\left[L_p - \frac{\pi}{2}(D+d)\right]^2 - 2(D-d)^2}\right\}$$

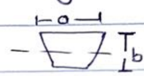


D: diameter of larger sheave

d: 〃 〃 smaller 〃

L_i is the standard, After calculating L_p:-

$$L_{in} = L_p - \Delta L$$



ΔL: from Table 17-11

Table 17-10 ; Standard L_{in}

So : Find ΔL that can be added to L_{in} standard to reach L_p calculated

Note:-

Center distance recommended:-

$$D < C < 3(D+d)$$

V-Belt Rated capacity

Table [17-12]

H_R = H tabulated at

$\emptyset = 180°$ → if $\emptyset < 180°$ → use K_1

L_p standard → if L_p not → use K_2

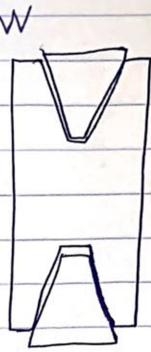
Also we use K_s: surface or application factor

$$H = \frac{K_1 K_2 H_R}{K_s} \longrightarrow H_{nom} = \boxed{\frac{K_1 K_2 H_R}{K_s}} \leftarrow H_{all}$$

K_2 → from Table

K_1 → from Table 17-13 for $\emptyset_s$ or $\frac{D-d}{C}$

For Table 17-13



K_2 is from Table 17-14
If length is not give (Between two rows)
Take least to make power min

K_s from Table 17-15

Usually H_{nom} is Given, and H_R is obtained

V-Belt sheave angle

It is $<40°$ → wedging action
so Normal force ↑(3N) → friction force ↑ → Torque capacity ↑ (3T)

But efficiency decreases
So for V-Belt

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{\frac{f \phi_s}{\sin \beta}} \rightarrow f' = \frac{f}{\sin \beta} = 0.5123$$

To calculate Tension:-

$$F_c = K_c \left(\frac{V}{1000}\right)^2$$ K_c from Table 17-16

These are for All belts used:

$$H_{nom} = \frac{(F_1 - F_2)V}{33000} = \frac{T\omega}{63025} \quad (1)$$

$$\frac{F_1 - F_c}{F_2 - F_c} = e^{f' \phi_s} \quad (2)$$

If more than 1 Belt is used → N Belts
H_{nom} is divided by N → $H/\text{belt} = \frac{H_{nom}}{N}$

For each belt (19)

$\Delta F = F_1 - F_2 = \frac{33000\, H_{nom}}{V}$

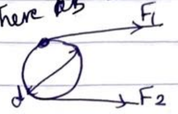
Another way

For each Belt ← $F_1 = F_c + \frac{\Delta F e^{f\phi}}{e^{f\phi} - 1}$

" " ← $F_2 = F_1 - \Delta F$

" " ← $F_i = \frac{F_1 + F_2}{2} - F$

There is bending

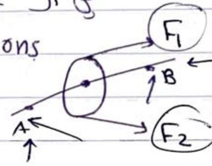


Bending

$F_{t_1} = F_1 + F_{b_1} = F_1 + \frac{K_b}{d}$ (Bending)

$F_{t_2} = F_1 + F_{b_2} = F_1 + \frac{K_b}{D}$ على البكرة الصغيرة

هاي القوى ما بتدخل في ال shaft Reactions



للأول لأنه أكبر وهو أقصى ال Tension في كل ال Belt

K_b bending factor from Table 17-16

Relation between tension force and number of cycles

$F_t^{\,b} N_p = K^b$ b, K constants Table 17-17

(N_p: Number of passes)

$N_p = \left[\left(\frac{K}{F_{t1}}\right)^{-b} + \left(\frac{K}{F_{t2}}\right)^{-b} \right]^{-1}$

life ⇒ $t = \frac{N_p L_p}{720 V}$ (hrs)

(L_p → inch, 720 → English, $V = \frac{\pi d n}{12}$ fpm)