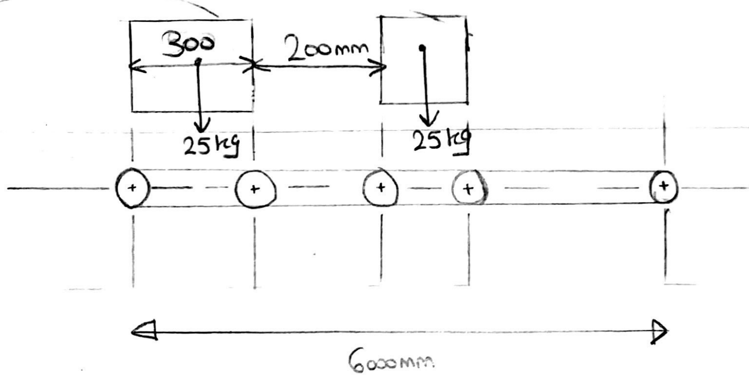
Project
Chain-Roller Conveyor

Description	Values
Conveyor Total length	6000 mm
Rollers Centre distance	250 mm
Linear Velocity	0.5 m/s & 0.7 m/s
Roller Diameter	100 → 150 mm
Box to Box distance	200 mm
Box Size	300x300x300 mm
Box weight	25 kg



* Firstly, we need to take the losses into our considerations. (V-Belt + Gearbox + Chain).

• Number of boxes : $\dfrac{\text{Total Distance}}{(\text{Rollers centre distance} + \text{Distance bet the boxes})}$

$$= \frac{6000}{(300+200)} = \boxed{12 \text{ boxes}}$$

• Weight of all boxes = weight of each box * Number of boxes =
$(12 * 25 * 10) = \boxed{3000\ N}$

• $Power_{@ V=0.5}$ = weight of the boxes * Velocity =
$3000 * 0.5 = \boxed{1500\ W}$

• Power @ $V=0.7 = 3000 * 0.7 = \boxed{2100\ W}$

• efficiency calculated $= (0.97)^4 = \boxed{0.885}$

$$Power\ Actual_{V=0.5} = \frac{1500}{0.885} = \boxed{1694.9W} \simeq \boxed{1695W}$$

$$Power\ Actual_{V=0.7} = \frac{2100}{0.885} = \boxed{2372.88W}$$

@ V= 0.5 m/s

d=50m

• $V = \omega r$

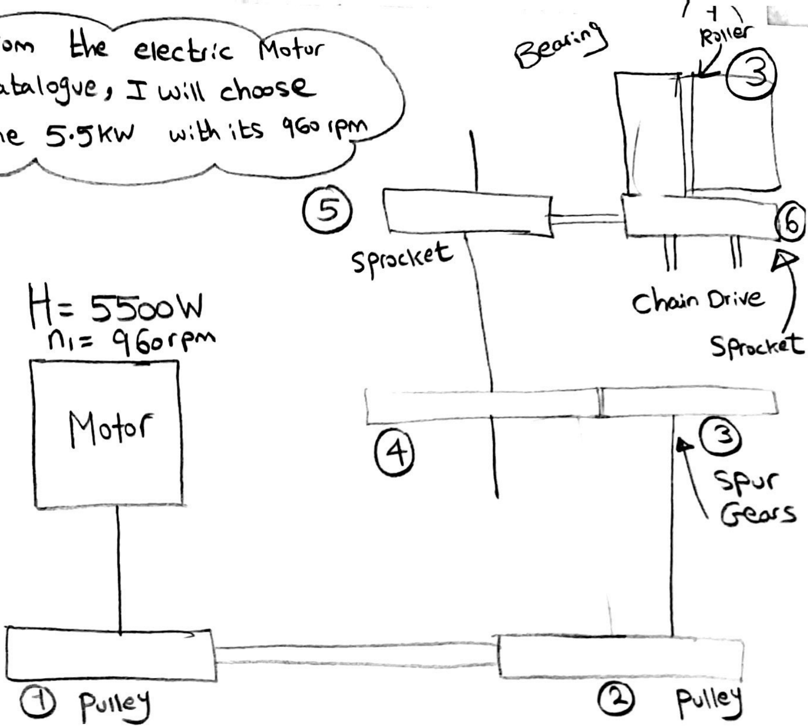
$$(0.5 * 10^3) = \frac{2\pi n_1}{60} * 50 , \boxed{n_1 = 100 \text{ rpm}}$$

@V= 0.7 m/s

$$(0.7 * 10^3) = \frac{2\pi n_2}{60} * 50$$

$$\boxed{n_2 = 134 \text{rpm}}$$

From the electric Motor Catalogue, I will choose the 5.5KW with its 960 rpm



Firstly

* Number of Boxes = $\boxed{12 \text{ boxes}} = \frac{6000}{300+200}$

Rollers = $\frac{\text{Total Distance}}{\text{Roller Centre Distance}} = \frac{6000}{250} = \boxed{24 \text{ rollers}}$

chains = $24 - 1 = \boxed{23 \text{ chains}}$

Belts

$\boxed{@\ V = 0.7}$

Total transmission ratio $= \dfrac{960}{134} = \boxed{7.16}$

$\hookrightarrow$ $i_B * i_{chain} * i_{Gears} = \boxed{1.5 * 1.5 * 3.184}$ respectively

① $H = 5500\,W$, $n_1 = 960$ rpm

$$H_{des} = H * S.F = \left(\frac{5500}{1000} * 1.3\right) = \boxed{7.15\ kW}$$

Type B

② Assume $\boxed{V = 20\ m/s}$

$$d_1 = \frac{60V}{\pi n_1} = \frac{60 * 20 * 10^3}{\pi * 960} = 397.88\,mm$$

Standard diameter : 400 mm

③ $i_{12} = \dfrac{n_1}{n_2} = \dfrac{d_2}{d_1}$,

$1.5 = \dfrac{960}{n_2} = \dfrac{d_2}{400}$, $\boxed{n_2 = 640\,rpm}$ $\boxed{d_2 = 600\ mm}$

Center distance

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

$600 < C < 3(600+400)$

$$\boxed{600 < C < 3000}$$

$$\boxed{\text{Let } C = 1200}$$

$$\theta_s = \pi - \left(\frac{d_2-d_1}{C}\right) = \pi - \left(\frac{600-400}{1200}\right)$$ (5)

$$= \boxed{2.97\ rad} = \boxed{170.45^\circ}$$

(4) $$L = 2C + \frac{\pi}{2}(d_2+d_1) + \frac{(d_2-d_1)^2}{4C}$$

$$= (2*1200) + \frac{\pi}{2}(600+400) + \frac{(200)^2}{4*1200},$$

$$2400 + 1570.796 + \frac{25}{3} = \boxed{3979.129}$$

Standard pitch length = $\boxed{4056\ mm}$

$$L_{in} = L - L_o = 4056 - 43 = \boxed{4013\ mm}$$

(5) $$H_{rat} = \left[k_1 V^{-0.09} - \frac{k_2}{De} - k_3 * 10^{-4} V^2\right] V$$

$\boxed{k_1 = 1.08}$, $\boxed{k_2 = 69.8}$, $\boxed{k_3 = 1.78}$, $\boxed{De = 175mm}$

$$De = d * ke = (400 * 1.11) = \boxed{\cancel{444}\ mm}$$

$$H_{rat} = \left[1.08(20)^{-0.09} - \frac{69.8}{175} - 1.78*10^{-4}*400\right] 20 =$$

$$\left[0.8247 - 0.3988 - 0.0712\right] 20 = \boxed{7.094\ hp} \approx$$

$$7.094 * 0.74 = \boxed{5.249KW}$$

⑥ $N = \frac{H_{des}}{K_L * K_A * H_{rat}} = \frac{7.15}{1.13 * 0.9809 * 5.249}$

$= 1.2$ belts $\simeq$ $\boxed{2 \text{ belts}}$

170	0.98
170.45	?
180	1

, $K_A = 0.9809$

⑦ $L = 2C' + \frac{\pi}{2}(d_1 + d_2) + \frac{(d_2 - d_1)^2}{4C'}$

$4056 = 2C' + \frac{\pi}{2}(1000) + \frac{(200)^2}{4C'}$

$16224\,C' = 8(C')^2 + 2000\pi C' + 40000$

$C' = 4.036\,m = \boxed{4036\,mm}$

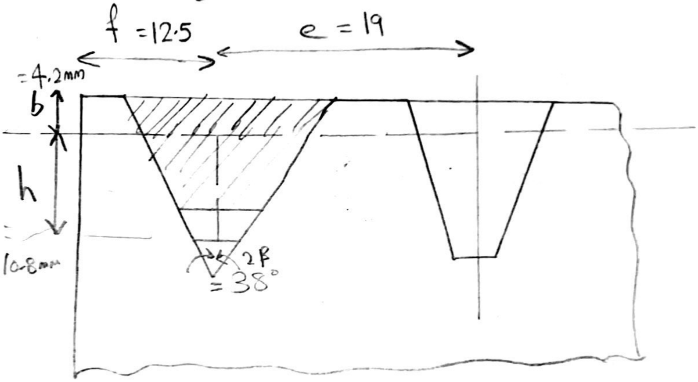
8 $\boxed{2\beta = 38}$

$e = 19$

$f = 12.5$

$W = (N-1)e + 2f = 19 + (2 * 12.5)$

$= \boxed{44 \text{ mm}}$



miller

Spur gears

1. $\boxed{i_{34} = 3.184}$, $\boxed{n_2 = n_3 = 640 rpm}$

$\boxed{N_3 = 18 \text{ teeth}}$

2. From the graph $\boxed{m = 4 mm}$

3. $d_3 = m N_3 = (4 * 18) = \boxed{72 \text{ mm}}$

$$i_{34} = \frac{d_4}{d_3} = \frac{N_4}{N_3} = \frac{n_3}{n_4}$$

$$3.184 = \frac{N_4}{18} , \quad N_4 = (18 * 3.184) = \boxed{58 \text{ teeth}}$$

$$d_4 = (m N_4) = (4 * 58) = \boxed{232 mm}$$

$$n_4 = \frac{n_3}{i_{34}} = \frac{640}{3.184} = \boxed{201.005 \text{ rpm}}$$

$$C_{34} = \frac{d_3 + d_4}{2} = \frac{72 + 232}{2} = \boxed{152 mm}$$

4. $F = 4\pi m = (4\pi * 4) = \boxed{50 mm}$

5. $\sigma = \dfrac{W_t}{F k_v m Y} = \dfrac{H/V}{F k_v m Y}$, $\boxed{V = \omega_3 r_3}$

$$V = \frac{2\pi n_3}{60} * r_3 = \frac{2\pi * 640}{60} * 36 = \boxed{2.412 m/s}$$

$$\omega_t = \frac{H}{V} = \frac{5.5 * 10^3}{2.412} = \boxed{2280.26 W}$$

$$K_v = \frac{6}{6+V} = \frac{6}{6+2.412} = \boxed{0.713}$$

$$\boxed{Y = 0.29327}$$

$$\sigma = \frac{W_t}{F k_v m Y} = \frac{2280.26}{50 * 0.713 * 4 * 0.29327} = \boxed{54.6M}$$

$$\sigma_{des} = 4\sigma = (4 * 54.6) = \boxed{218.4 \text{ MPa}}$$

(6) use 4140 OQT 1300

$S_y = 469$ MPa

$S_{ut} = 662$ MPa

HB = 200

(7) Endurance limit

$$\boxed{S_e = k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot k_f \, S_e'} \quad , \quad \boxed{S_e' = \frac{S_{ult}}{2}}$$

$$S_e' = \frac{662}{2} = \boxed{331 \text{ MPa}}$$

$\boxed{k_a = 0.73}$, $\boxed{k_b = 0.93}$, $\boxed{k_c = 0.814}$, $\boxed{k_d = k_e = k_f = 1}$

$$S_e = (0.73 * 0.93 * 0.814 * 331) = \boxed{182.9 \text{ MPa}}$$

Q = (Mining Conveyor) = 6
$K_v = 0.8$ from the graph
$J = 0.325$

$$\sigma_a = \frac{W_t}{K_v F m J} = \frac{2280.26}{0.8 * 50 * 4 * 0.325} = \boxed{43.85 \text{ MPa}}$$

$$n = \frac{n_G}{k_o \cdot k_m} = \frac{S_e / \sigma_a}{k_o \cdot k_m} = \frac{182.9 / 43.85}{1.4 * 1.25} = \boxed{2.38 > 1 \text{ , safe}}$$

8) $S_c = (2.76HB - 70) = (2.76*200 - 70) = \boxed{482 \text{ MPa}}$

$\boxed{C_H = 1}$, $\boxed{C_T = 1}$, $\boxed{C_L = 1}$, $\boxed{C_R = 0.8}$

$$S_H = \frac{C_L \cdot C_H}{C_T \cdot C_R} * S_c = \frac{482}{0.8} = \boxed{903.75 \text{ MPa}}$$

$$\sigma_H = C_p \sqrt{\frac{W_{t,P}}{C_v F d_1 I}} = 191 \sqrt{\frac{2280.26}{0.8 * 50 * 72 * 0.11}} =$$

$\boxed{512.42 \text{ MPa}}$

$$S_H = \sqrt{K_o k_m n} \; \sigma_H ,$$

$$903.75 = \sqrt{1.4 * 1.25 n} * 512.42$$

$\boxed{n = 1.77 > 1.3 \text{ , Safe}}$

Chains

Given

1. $\boxed{H = 5.5\,kw}$, $n_4 = n_5 = \boxed{201\ rpm}$

or, $(134 * 1.5) = \boxed{201\ rpm}$

$$kw\ \text{rating of chain} = \frac{kw\ \text{transmitted} * k_s}{k_1 * k_2}$$

$$= \frac{(5.5 * 1.3)}{(1 * 1.26)} = \boxed{5.674\ kw}$$

2. Selection of chain

$\boxed{16\ A}$ $\boxed{P = 25.4\,mm}$, $\boxed{n_5 = 201\ rpm}$

$\boxed{kw_{rat} = 5.674\ kw}$

3. $$D_1 = \frac{P}{\sin\left(\frac{180}{z_1}\right)} = \frac{25.4}{\sin\left(\frac{180}{21}\right)} = \boxed{170.42\,mm}$$

$$i_{56} = \frac{z_2}{z_1}\ ,\quad z_2 = (1.5 * 21) = 31.5 \simeq \boxed{32\ \text{teeth}}$$

$$D_2 = \frac{P}{\sin\left(\frac{180}{z_2}\right)} = \frac{25.4}{\sin\left(\frac{180}{32}\right)} = \boxed{259.13\,mm}$$

4. $a = 40P = (40 * 25.4) = \boxed{1016\ mm}$

$$L_n = 2\left(\frac{a}{P}\right) + \left(\frac{Z_1+Z_2}{2}\right) + \left(\frac{Z_2-Z_1}{2\pi}\right)^2 * \frac{P}{a} =$$

$$2\left(\frac{1016}{25.4}\right) + \left(\frac{32+21}{2}\right) + \left(\frac{32-21}{2\pi}\right)^2 * \frac{25.4}{1016} =$$

$\boxed{\text{106 links}}$

(5) $$a = \frac{P}{4}\left\{\left[L_n - \left(\frac{Z_1+Z_2}{2}\right)\right] + \sqrt{\left(L_n - \left(\frac{Z_1+Z_2}{2}\right)\right)^2 - 8\left(\frac{Z_2-Z_1}{2\pi}\right)^2}\right\}$$

$$= \frac{25.4}{4}\left\{\left[\left(106 - \left(\frac{32+21}{2}\right)\right]\right. + \left.\sqrt{\left(106 - \left(\frac{32+21}{2}\right)\right)^2 - 8\left(\frac{9}{2\pi}\right)^2}\right\}$$

$$, 6.35\left\{(79.5) + \sqrt{(79.5)^2 - 16.41}\right\} =$$

$$6.35(158.896) = \boxed{1008.99\,\text{mm}}$$

$\boxed{@ V = 0.5}$

Given $H = 5500\,W$,

Total transmission ratio $= \frac{960}{100} = \boxed{9.6}$

* We should apply the Constraint of equalizing the transmission ratios of the belts & the chains in both the velocities (0.5 m/s & 0.7 m/s).

$$i_{Tot} = i_{Belts} * i_{chain} * i_{spurgear}$$
$$= 1.5 * 1.5 * 4.266$$

Spur Gears

(1) $\boxed{N_3 = 23 \text{ teeth}}$, $n_3 = \frac{960}{1.5} = \boxed{640 \text{ rpm}}$ ~~teeth~~

(2) $= 2.5\,mm =$ module

$d_4 = mN_4 =$ $(3*$

(3) $d_3 = mN_3 = (2.5 * 23) = \boxed{57.5\ mm}$

$$n_4 = \frac{n_3}{i_{34}} = \frac{640}{4.266} = \boxed{150.023\ rpm}$$

$$4.266 = \frac{N_4}{23},\ \boxed{N_4 = 98 \text{ teeth}}$$

$$d_4 = mN_4 = (98 * 2.5) = \boxed{245\ mm}$$

$$C = \frac{d_3 + d_4}{2} = \frac{245 + 57.5}{2} = \boxed{151.3\,mm}$$

$M =$

④ $F = (4\pi m) = (4 * \pi * 2.5) = \boxed{31.41\,mm}$ 14

⑤ $\sigma = \dfrac{W_t}{F K_v m Y}$

$w_t = \dfrac{H}{V} = \dfrac{5500}{\left(\dfrac{2\pi * 640}{60} * 28.75\right)} = \dfrac{5500}{1.926}$

$= \boxed{2855.65\,W}$

$k_v = \dfrac{6}{6+v} = \dfrac{6}{6+1.926} = \boxed{0.757}$

$\sigma = \dfrac{2855.65}{31.41 * 0.757 * 2.5 * 0.29317} = \boxed{165.336\,MPa}$

$\sigma_{des} = 4 * \sigma = (4 * 165.336) = \boxed{661.345\,MPa}$

⑥ Select OQT 700
$S_{ut} = 1590\,MPa$
$S_y = 1460\,MPa$
$HB = 461$

$S_e' = \dfrac{S_{ut}}{2} = \dfrac{1590}{2} = \boxed{795\,MPa}$

$S_e = k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot k_f \cdot S_e'$

$\boxed{k_a = 0.63}$, $\boxed{k_b = 0.974}$, $\boxed{k_c = 0.814}$

$\boxed{k_d = k_e = k_f = 1}$

$= (0.63 * 0.974 * 0.814 * 1 * 795) = \boxed{397\,MPa}$

$\boxed{J=6}$, $\boxed{K_v=0.8}$, $\boxed{J=0.32}$ 15

b) $\sigma_a = \dfrac{W_t}{K_v F m J} = \dfrac{2855.65}{0.8*31.41*2.5*0.32} = \boxed{142.05\ MPa}$

$n = \dfrac{S_e/\sigma_a}{K_o \cdot K_m} = \dfrac{397/142.05}{1.3*1} = \boxed{2.149 \geq 1 \text{ , safe}}$

8 $S_c = 2.76HB - 70 = (2.76*461) - 70 = \boxed{1202.36\ MPa}$

$\boxed{C_H=1}$, $\boxed{C_T=1}$, $\boxed{C_R=1}$, $\boxed{C_L=1.3}$

$\sigma_H = C_p \sqrt{\dfrac{W_t p}{C_v F d_1 I}} = 191 \sqrt{\dfrac{2855.65}{0.8*31.41*57.5*0.122}}$

$= \boxed{768.76\ MPa}$

$S_H = \sqrt{K_o \cdot K_m \cdot n}\ \sigma_H$

$1563.068 = \sqrt{1.3*1.3*n} * 768.76$

$\boxed{n = 2.54 \geq 1 \text{ , safe}}$

$S_H = \dfrac{C_L C_H}{C_T C_R} S_c$

$= \dfrac{1202.36 * 1.3}{1}$

$= \boxed{1563.068\ MPa}$

Scanned with CamScanner

$\boxed{@\ V = 0.5\ m/s}$

as @ V = 0.5 , n_5 = 100 rpm , like mentioned before , so we will multiply it by 1.5 , as it is the transmission ratio of the chain.

$$n_5 = 1.5 * 100 = \boxed{150\ rpm}$$

(1) $$\boxed{KW_{rating} = \frac{kw\ transmitted * K_s}{K_1 * K_2}} = \frac{5.5 * 1.3}{1.26} = \boxed{5.67\ KW}$$

Interpolation

100	4.83
150	?
200	8.94

$\boxed{Pow = 6.885\ KW}$

(2) Select from table 16 B

$\boxed{Pitch = 19.05\ mm}$

(3) $$D_1 = \frac{P}{\sin\left(\frac{180}{z_1}\right)} = \frac{25.4}{\sin\left(\frac{180}{21}\right)} = \boxed{170.816\ mm}$$

$$i_{56} = \frac{z_2}{z_1} , \quad 1.5 = \frac{z_2}{21} , \quad \boxed{z_2 = 32\ teeth}$$

$$D_2 = \left(\frac{P}{\sin\left(\frac{180}{z_2}\right)}\right) = \frac{25.4}{\sin\left(\frac{180}{32}\right)} = \boxed{259.13\ mm}$$

(4) $$a = 40P = (40 * 25.4) = \boxed{1016\ mm}$$

(17)

$$L_n = 2\left(\frac{a}{P}\right) + \left(\frac{Z_1+Z_2}{2}\right) + \left(\frac{Z_2-Z_1}{2\pi}\right)^2 * \frac{P}{a} =$$

$$2\left(\frac{1016}{25.4}\right) + \left(\frac{32+21}{2}\right) + \left(\frac{9}{2\pi}\right)^2 * \frac{25.4}{1016} = \boxed{106 \text{ links}}$$

(5) $$a = \frac{P}{4}\left\{\left[L_n - \left(\frac{Z_1+Z_2}{2}\right)\right] + \sqrt{\left(L_n - \left(\frac{Z_1+Z_2}{2}\right)\right)^2 - 8\left(\frac{Z_2-Z_1}{2\pi}\right)^2}\right\} =$$

$$\frac{25.4}{4}\left\{\left[106 - \left(\frac{32+21}{2}\right)\right] + \sqrt{(106 - (26.5))^2 - 8\left(\frac{9}{2\pi}\right)^2}\right\},$$

$$6.35\{(79.5) + 79.3916\} = \boxed{1009\ \text{mm}}$$

$\omega = \frac{2\pi n}{60}$

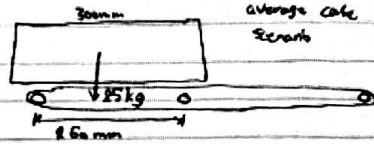
$n = \frac{60}{2\pi}\omega$

Bearings (Deep groove)

Total distance = 6000 mm

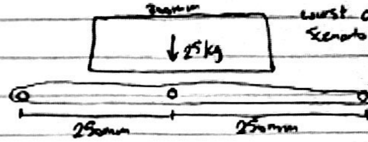
12 boxes $\Longrightarrow$ 3000 N

24 rollers



In average case scenario

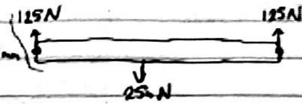
roller force = $\frac{3000}{24}$ = 125 N (half box)



In worst case scenario

roller force = $\frac{3000}{12}$ = 250 N (one box)

Working on <u>worst</u> case scenario



$F_r = 125\,N$, $F_a = 0$, $d_o = 25\,mm$, $d_i = 12.5\,mm$

Case of radial load only:

$P = 125\,N$, & taking $K_{sf} = 1.1$

$P' = 125 \times 1.1 = 137.5\,N$

choosing $L = 25000$, roller diameter = 40mm

$\omega = 0.7 \times \frac{1}{\frac{40\times10^{-3}}{2}} = 35$ rad/s $\qquad n = \frac{60}{2\pi}(35) = 334.2$ rpm

V

$$C = 137.5 \times \left(\frac{60 \times 25000 \times 334.2}{10^6}\right)^{\frac{1}{3}}$$

$C = 1092.3\,N$

choosing ~~...~~ Deep Groove Bearing (6205 ~~...~~) $\quad$ ($d = 25\,mm$, $D = 52\,mm$)

~~$C_{tab} = 2250\,N$, $C_{0tab} = 950\,N$, $n_{tab} = 36000$ rpm~~

$C_{tab} = 14000\,N$, $C_{0tab} = 7800\,N$, $n_{tab} = 15000$ rpm

$C_0 = 1 \times 125 = 125\,N$

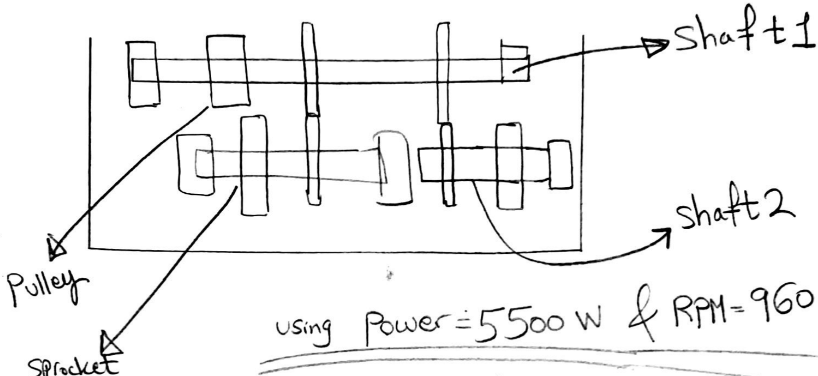
$C = 1092.3\,N < \cancel{2250}\ 14000\,N$

$C_0 = 125\,N < \cancel{950}\ 7800\,N$

$n = 334.2$ rpm $< \cancel{36000}\ 15000$ rpm

<u>Safe</u>

Shaft Diameter Calculated for Gearbox on both Velocities.



using Power = 5500 W & RPM = 960

* Diameter of Pinion = 500 mm
* ① // // Gear = 1000 mm

$$\boxed{\frac{F_1}{F_2} = e^{\mu v}}$$

$2\beta = (2 * 17) = \boxed{34^\circ}$

$\boxed{\text{Assume } \mu = 0.4}$

$$\mu_v = \frac{\mu}{\sin\beta} = \frac{0.4}{\sin(17)} = \boxed{1.368}$$

$\boxed{\text{Assume wrap angle} = 160^\circ}$

in rad, $\frac{160 * \pi}{180} = \boxed{2.792 \text{ rad}}$

Substitute in ①, $\frac{F_1}{F_2} = e^{1.368 * 2.792} = \boxed{45.579}$

$$\boxed{F_2 = \frac{F_1}{45.579}}$$

$$H = (F_1 - F_2)V$$

$$5500 = \left(F_1 - \frac{F_1}{45.579}\right) \cdot \omega r$$

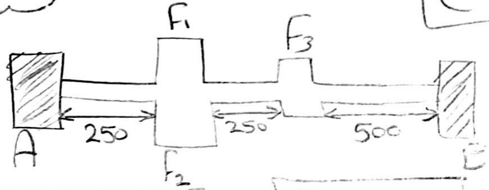
$$5500 = \left(F_1 - \frac{F_1}{45.579}\right) \cdot \left(\frac{2\pi * 960}{60} * \frac{0.1}{2}\right)$$

$\boxed{F_1 = 1118.735\,N}$, $F_2 = \frac{1118.735}{45.579} = \boxed{24.54\,N}$

Let shaft length = $\boxed{1000\,mm}$

$\boxed{@\ V = 0.7\ m/s}$

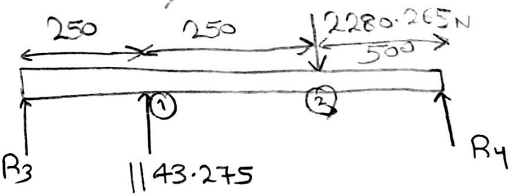
Horizontal



$\boxed{F_1 = 1118.735\,N}$ $\boxed{F_2 = 24.54\,N}$, $F_3 = \frac{5500}{2.412} = \boxed{2280.265\,N}$

$F_4 = (2280.265 \tan(20)) = \boxed{829.948\,N}$

For horizontal



$\Sigma M @ R_4 = 0$

$(1000 * R_3) + (1143.275 * 750) - (2280.265 * 500) = 0$

$\boxed{R_3 = 282.67\,N}$

$\Sigma F_y = 0$

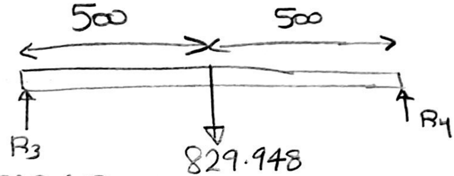
$282.67 + 1143.275 - 2280.265 + R_4 = 0$

$$\boxed{R_4 = 854.32\,N}$$

$M_{b_1} = (250 R_3) = (250 * 282.67) \; \boxed{70667.5\,Nmm}$

$M_{b_2} = (500 R_4) = (500 * 854.32) = 427160\,Nmm$

Vertical



$R_3 = R_4 = \dfrac{829.948}{2} = \boxed{414.974\,N}$

$M_{b_2} = (500 * 414.974) = \boxed{207.487\,Nm}$

$M_{b\,max} = \sqrt{427.160^2 + 207.487^2} = \boxed{474.885\,Nm}$

$Torque = \dfrac{Power}{omega}, \; T = \dfrac{5500}{\frac{2\pi * 640}{60}} = \boxed{82.064\,Nm}$

$$\boxed{M_{t\,max} = 82.064\,N{\cdot}m}$$

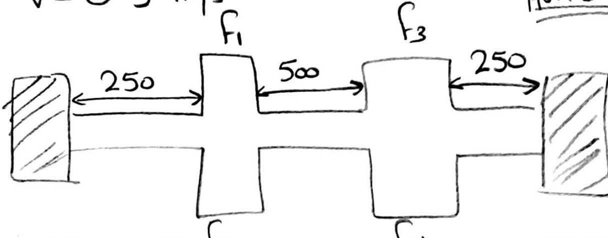
F_r on bearing $A = \sqrt{282.67^2 + 414.974^2} = \boxed{502.101\,N}$

F_r on bearing $B =$

$\sqrt{854.32^2 + 414.974^2} = \boxed{949.77\,N}$

@ V = 0.5 m/s

Horizontal



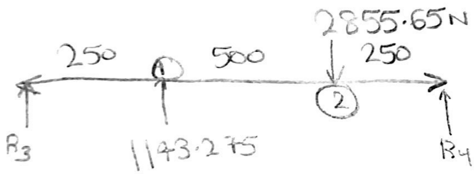
$\boxed{F_1 = 1118.735\,N}$

$\boxed{F_2 = 24.54\,N}$

$F_3 = \frac{5500}{1.926} = \boxed{2855.65\,N}$

$F_4 = (2855.65 \tan(20)) = \boxed{1039.37\,N}$

Horizontal



$\boxed{\Sigma M_{R4} = 0}$

$$(1000 R_3) + (1143.275 * 750) - (2855.65 * 250) = 0$$

$\boxed{R_3 = 143.54\,N}$

$\Sigma f_y = 0$

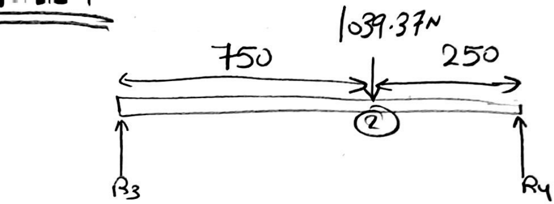
$$143.54 + 1143.275 + R_4 - 2855.65 = 0$$

$\boxed{R_4 = 1568.835\,N}$

$M_{b1} = (0.25 * 143.5435) = \boxed{35.8858\,Nm}$

$M_{b2} = (0.25 * 1568.835) = \boxed{392.208\,NM}$

Scanned with CamScanner



$\Sigma M_{R4} = 0$

$$(1000 * R_3) - (1039.37 * 250) = 0$$

$$\boxed{R_3 = 259.8425\,N}$$

$$R_4 = 259.8425 - 1039.37 = \boxed{779.527\,N}$$

$$M_{b2} = (0.2 * 779.527) = \boxed{155.9055\,Nm}$$

$$M_{bmax} = \sqrt{392.208^2 + 155.9055^2} = \boxed{422.058\,Nm}$$

$$M_t = \frac{P}{\omega} = \frac{5500}{\frac{2\pi * 640}{60}} = \boxed{82.064\,Nm}$$

Fr on bearing A :

$$\sqrt{143.54^2 + 259.84^2} = \boxed{296.851\,N}$$

fr on bearing 2: $\sqrt{779.527^2 + 1568.835^2} = \boxed{1751.82N}$

Take the max moment = $\boxed{422.058\,Nm}$

$$\boxed{M_t = 82.064\,Nm}$$

Scanned with CamScanner

6

$$S_y = 250\ MPa$$
$$\tau_y = 125\ MPa$$
$$\tau_{all} = 62.5\ MPa$$
$$n = 2$$
$$k = 0.6$$
$$k_b = 1.7$$
$$k_t = 1.3$$

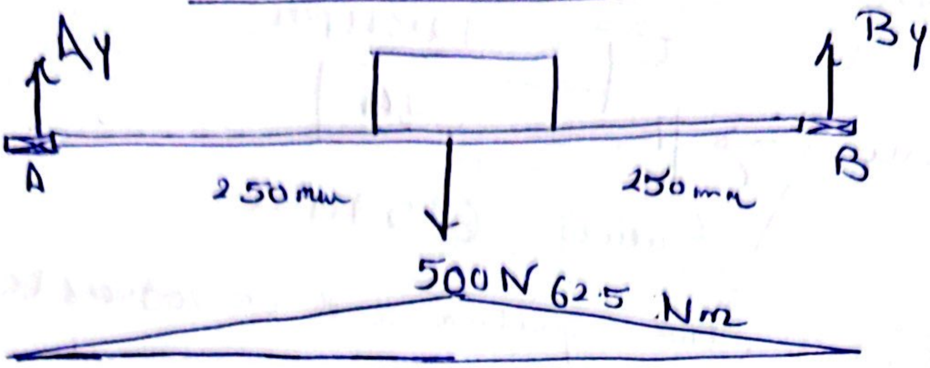
$$d_o^3 = \frac{16}{\pi * 62.5 * 10^6 (1 - 0.6^4)} *$$

$$\sqrt{(1.7 * 422.058)^2 + (1.3 * 82.064)} = 6.71 * 10^{-5}$$

$$d_o = (ANS)^{1/3} = 0.04065\ m$$

$$\boxed{d_o = 40.65\ mm}$$

Shaft calculations



$\sum M_A = 0$

$-500 * 250 + B_y * 500 = 0$

$\boxed{B_y = 250\ N}$

$\sum F_y = 0$

$A_y = 250\ N$

N.B : in reality the Shaft carries the 500N but we Consider 500 N for Saftey

* for factor of Safety $\boxed{2}$

* $w = \frac{2\pi * 134}{60} = \frac{67}{15}$ rad s^{-1}

* $\boxed{5500\ w = H}$

* $M_{t\,max} = \frac{5500}{14.03} = 392\ Nm$

* $M_b = 62.5\ Nm$
  $* 2 = \boxed{125\ Nm}$

Scanned with CamScanner

:

* choose $\overline{OQT\,1000} \rightarrow S_y = 1050\,MPa$

* $\tau_y = \frac{1050}{2} = 525\,MPa$

* assume $K = 0.5$ * $\tau_{allow} = \frac{525}{2} = 262.5$ (failed) MPa

* choose $\overline{ST50} \rightarrow S_y = 250\,MPa$, $\tau_y = 125\,MPa$, $\tau_{allow} = 62.5\,MPa$

* $$d_o^3 = \frac{16}{\pi * \underset{\substack{\text{or } 62.5 \\ \downarrow \\ ST50}}{\underbrace{262.5}_{\rightarrow \overline{OQT1000}}} * (1 - 0.5^4) * 10^6} * \sqrt{(3 * (125))^2 + (3 * 392)^2}$$

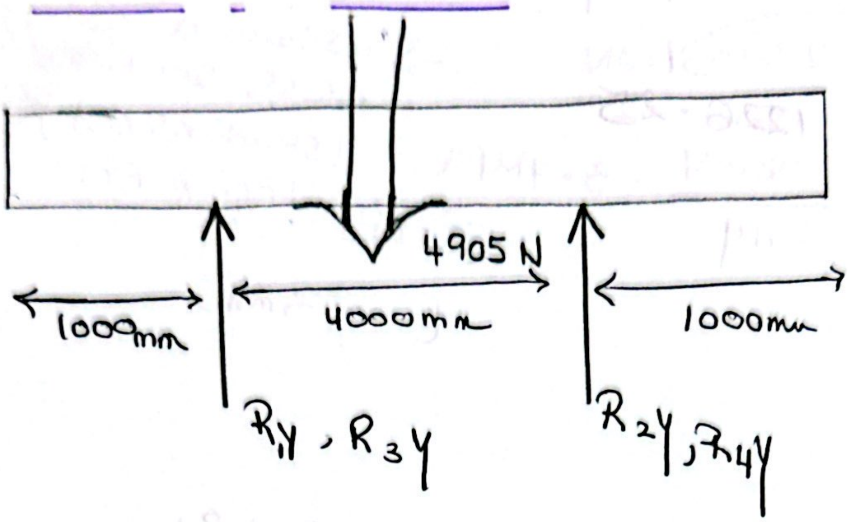
$= N$ Material used

* $d_o = 0.05\,m * 1000 = \boxed{50\,mm}$ for ST50

↳ choose 45mm Standardized cross section or press fit some shaft in the roller

* $\boxed{d_i = 25\,mm}$

* frame calculations



* assuming no distances between the boxes
  - → the total number of boxes is $\boxed{20}$
  - → weight = 20 * 25 = 500 kg * 9.81 = 4905 N
    (weight is distributed between 4 table legs)

$$\Rightarrow \sum M_{R_{2y}, R_{4y}} = 0$$

* $R_{1y} = R_{3y}$
* $R_{2y} = R_{4y}$

$$-2R_{1y} * 4000 + 4905 * 2000 = 0$$

$$\boxed{R_{1,3\,y} = 1226.25\ N}$$

$$\sum F_y = 0$$

$$2 * 1226.25 - 4905 + 2 * R_{2y} = 0$$

$$\boxed{R_{2y} = 1226.25\ N}$$

assuming $\boxed{FOS = 2}$

$\Rightarrow \boxed{T.\ Force = 4905\ N} \rightarrow \boxed{Force\ @\ 1\ leg = 1226.25\ N}$

$F = 1226.25 \times 2.5 \approx 3100N$ $\Rightarrow$ assume a rectangular hollow cross section (standardized) $\rightarrow \boxed{A = 914\ mm^2}$

$\sigma = \dfrac{3100\ N}{914} = 3.4\ MPa$

$D \times B = 100_{mm} * 60_{mm}$

$t = 3mm$

$\boxed{F.S = 2}$

$2 = \dfrac{S_{ut}}{3.4} \Rightarrow S_{ut} = 6.8\ MPa$ (iteration failed)

assume the material to be used (Hot rolled 1020 Carbon Steel with $S_{ut} = 379 MPa$.

$2 = \dfrac{379}{\sigma}$

$\sigma = 190 MPa$

$190 = \dfrac{3100N}{A}$

$A = 16.3\ mm^2 \longrightarrow$ nearest standardized cross-section is 12m * 12m Square hallow cross section with thickness $\boxed{1}$

$\Rightarrow \sigma = \dfrac{3100}{42} = 74 MPa$

$n = 379/74 = \boxed{5}$ $\Rightarrow$ Suitable to handle belding