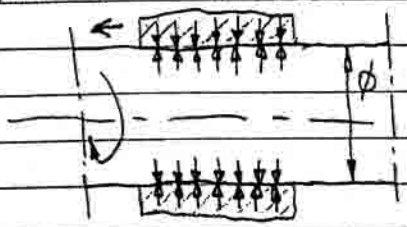
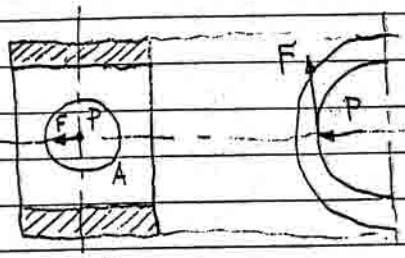
STROJNI ELEMENTI II

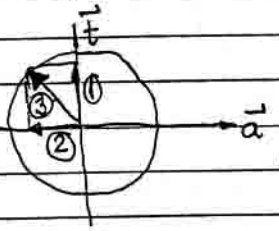
2000 / 2001

Predmet

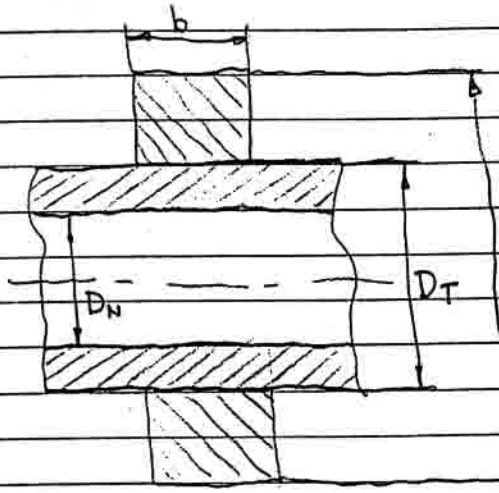
KRČNI NASED

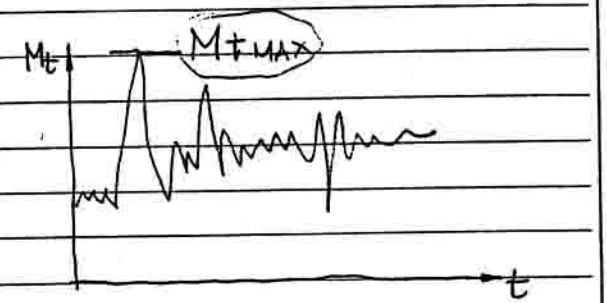


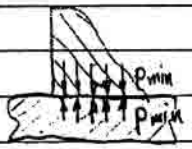




① samo radialne sile
② samo aksialne sile
③ obe: merodajna je rezultanta







$(\mu_m \cdot p_{min}) \cdot \pi \cdot D_T \cdot L \cdot \frac{D_T}{2} \geq M_{t\,MAX}$

$(\mu_m \cdot p_{min}) \cdot \pi \cdot D_T \cdot L \cdot \frac{D_T}{2} = S \cdot M_{t\,MAX}$

Dinamične obremenitve $\mu_m \rightarrow \mu_s$ $S = 1$

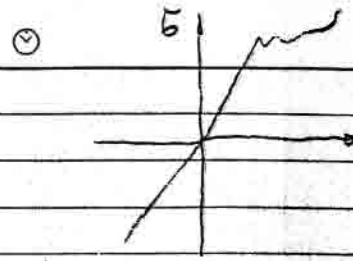
$S = 1{,}5 \div 2$ če ne poznamo μ_m in $M_{t\,max}$

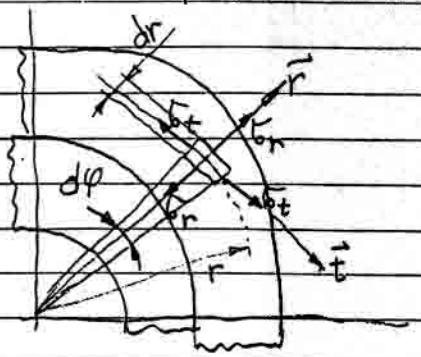
$p_{min} = ?$

-Sedaj smo zagotovili tip. Preveriti moramo če se stvar vzdrži (notranji del ležajno ni kritičen, saj tlak bolje prenaša kot nateg)

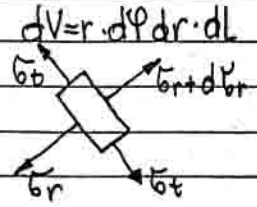
-Kako ga sestavimo? Predvidimo toleranco, ki da zadosten tlak. Gred ohladimo in sestavimo s pestom.

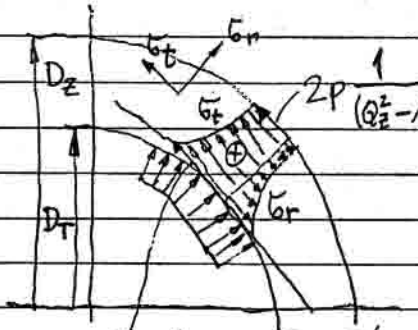
Predmet



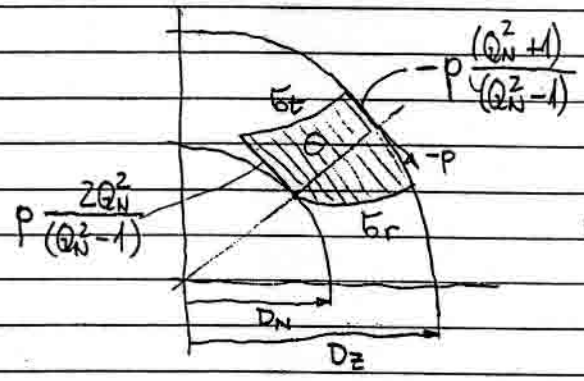


$dV = r \cdot d\varphi \, dr \cdot dl$



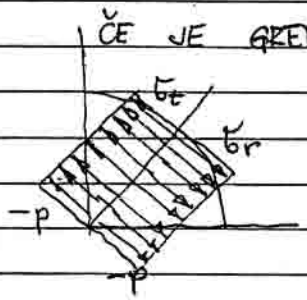


$Q_z = \frac{D_z}{D_T}$

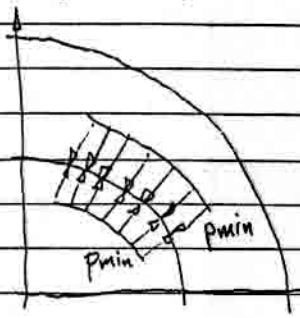


$Q_N = \frac{D_T}{D_N}$

ČE JE GRED POLNA



sodečega v praksi ne preverjamo pogosto.



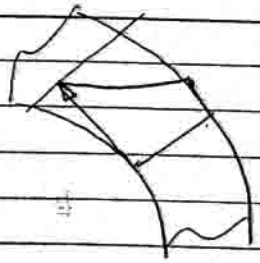
ali bo p_{min} porušil kateri obroč

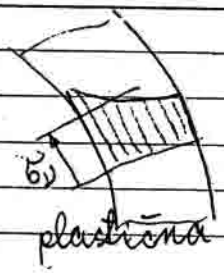
$\sigma_{TDT} = +p_{min}\left(\frac{Q_z^2+1}{Q_z^2-1}\right)$ $\qquad \sigma_{RDTz} = -p_{min}$

$\sigma_{TDN} = -p_{max}\left(\frac{2Q_N^2}{Q_N^2-1}\right)$ $\qquad \sigma_{RDN} = \emptyset$

$\sigma_{TDTz} \leq 0{,}9\,\sigma_{\gamma z}$ (zunanji obroč) $\qquad \sigma_{TDN} \leq 0{,}9\,\sigma_{\gamma N}$

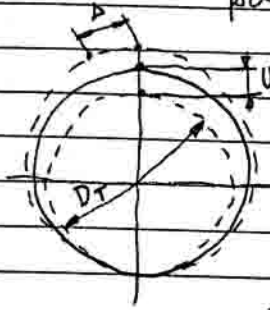
Predmet





plastična deformacija

Tema računa: dimenzioniranje v področju plastičnosti !!!
kako povečati μm ... povečanji globkosti ni priporočljivo kvizgulimo z predpisano nadmero !!!

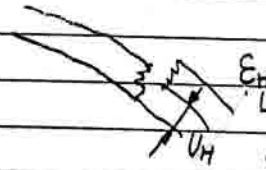


$$\varepsilon_H = \frac{\Delta}{OBC} = \frac{\Delta}{\pi D_T} = \frac{\Delta(D_T + U_H) - \pi D_T}{\pi D_T} = \frac{U_H}{D_T}$$

ε_H ... specifični raztezek

$$\varepsilon_{Hz} = \frac{1}{E_z}\left(\sigma^{+}_{TDTz} - \frac{1}{m}\sigma_{RDTz}\right)$$

σ^{+} ... zunanji obroč v vzvezi s Poissonom



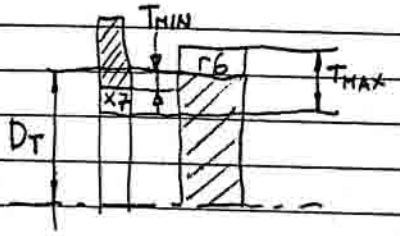
$\varepsilon_H = \varepsilon_{Hz} - \varepsilon_{HN}$
↳ toplotna specifična deformacija

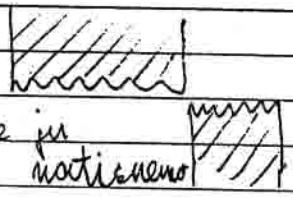
$$\varepsilon_{HN} = \frac{1}{E_N}\left(\sigma_{TDTN} - \frac{1}{m}\sigma_{RDTN}\right)$$

$$\varepsilon_H = \varepsilon_{Hz} + \varepsilon_{HN}$$

ε_H je večji kot bi bil če notranji obroč nebi počil.

$$U_H = D_T \cdot \varepsilon_H$$





če jih natisnemo

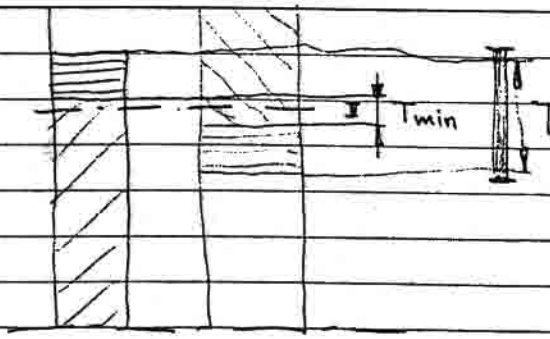
$\Rightarrow$

$$U_{MIN} = U_{HMIN} + 2(0.6R_{zz} + 0.6R_{zN})$$

$$U_{MIN} < T_{MIN}$$

$p_{min} = \surd$
$\sigma_{TDTz} = ?$
$\sigma_{RDRz} = ?$
$\sigma_{TDTN} = ?$
$\varepsilon_{Hz} = ?$
$\varepsilon_{HN} = ?$
$\varepsilon_H = \varepsilon_{Hz} - \varepsilon_{HN}$
$U_{H\,min} = ?$

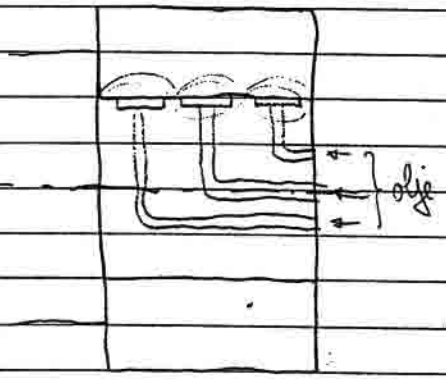
Predmet



$T_{min} > U_{min}$
$T_{max} < U_{max}$

$\alpha \cdot D_T (\vartheta_z^s - \vartheta_N^o) > T_{max}$ ↔premajhna rezerva zato

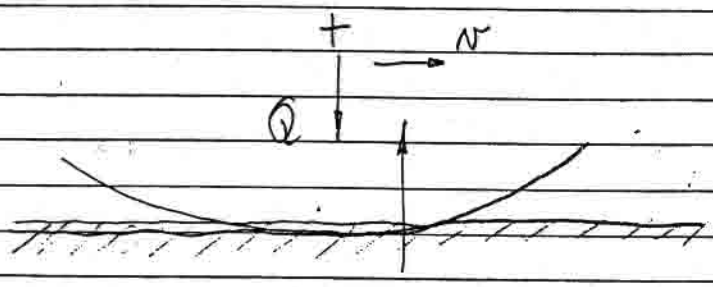
$\alpha D_T (\vartheta_z^s - \vartheta_N^o) = T_{max} + \frac{D_T}{1000}$

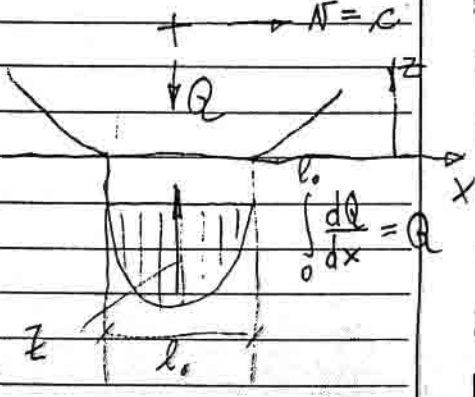


GONILA

Transformacija energije s čim večjim izkoristkom

~~TORNA~~ ~~GONILA~~





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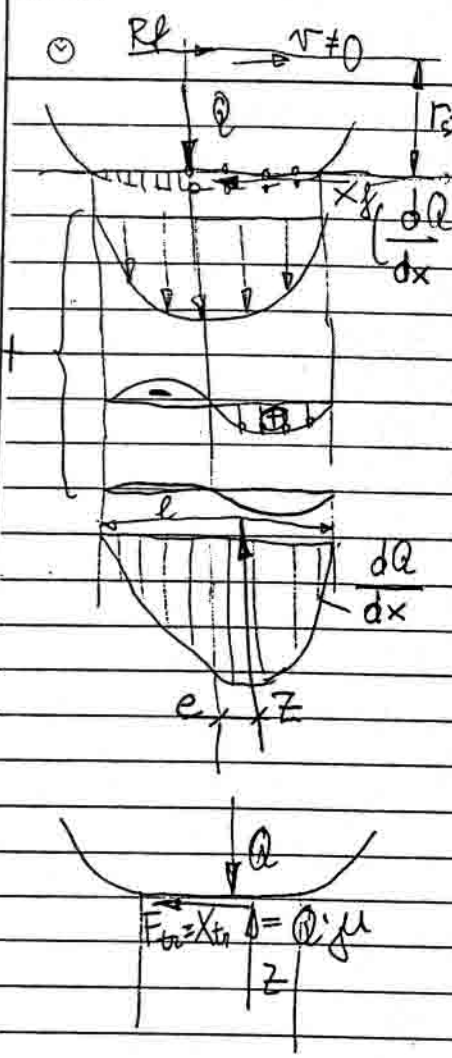


statični polmer kolesa

$\Sigma F_{iz} = 0$

$\Sigma F_{ix} = 0$

$\Sigma M_{xz} = 0$

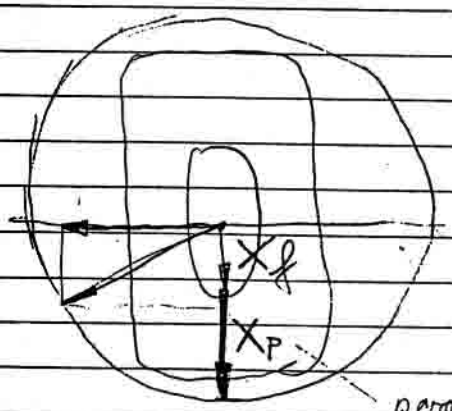
$Q = Z$

$Z \cdot e = R_f \cdot r_{st}$

$R_f = Z\left(\frac{e}{r_{st}}\right) = Z \cdot f$

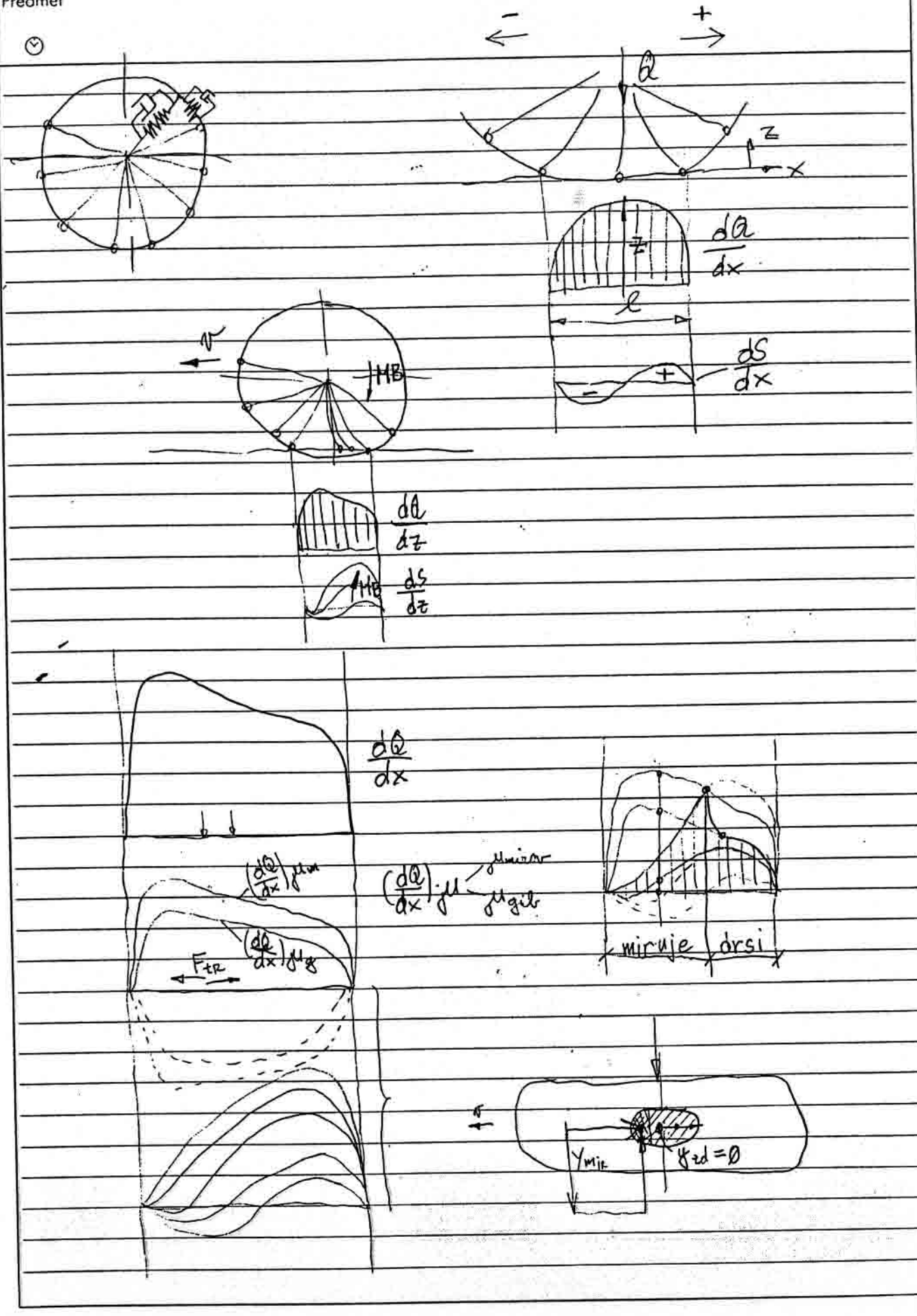
$Rl = X$

$X_f \leq X_{tr}$



pogonska sila

Predmet



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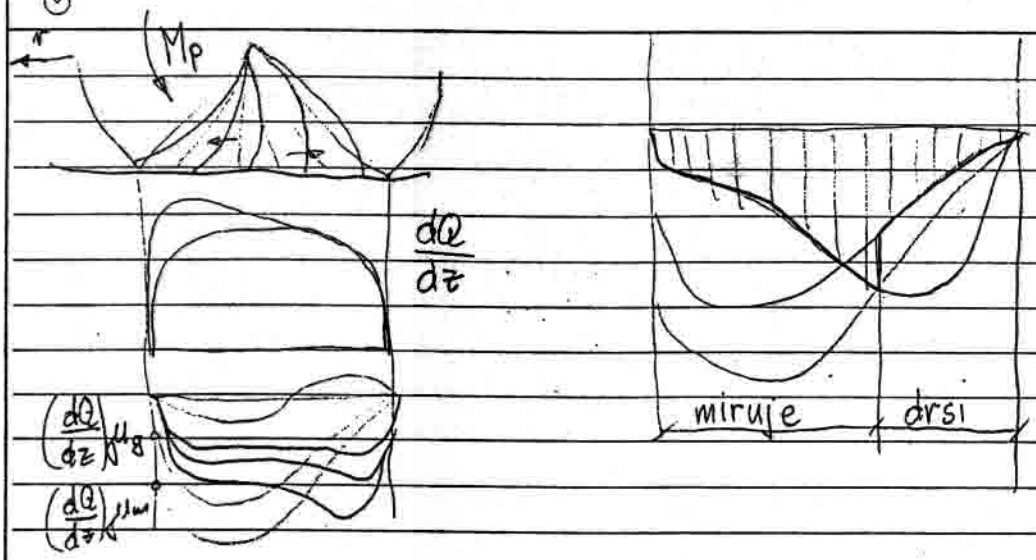
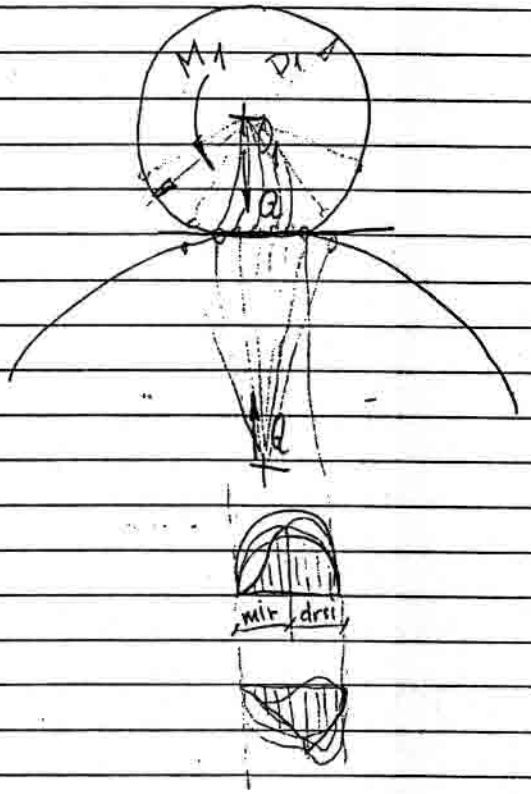
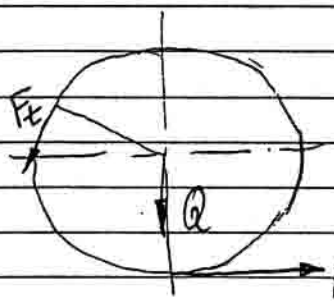




$$\left(Q \cdot \mu_{(g)}^{(m)}\right) > F_t$$

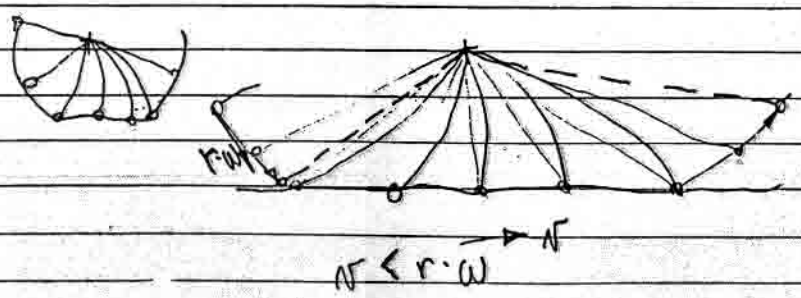


$Q \cdot \mu'_m = F_{tr_m}$

$Q \cdot \mu'_g = F_{tr_g}$

$\mu_H = \frac{F_t}{F_{tr}}$ - koef. sprijemanja

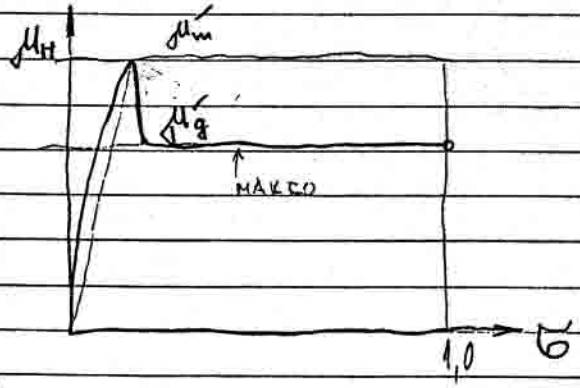
$0 \leq \mu_H \leq \mu'_g$

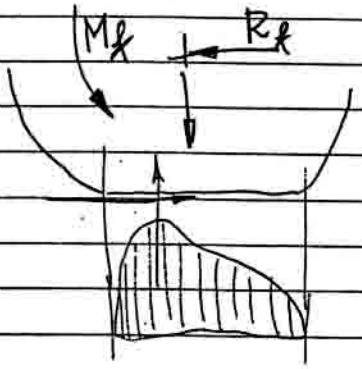


Predmet

$\delta = \frac{r\cdot\omega - N}{r\cdot\omega}$ – specifično spodrsavanje

$0 \le \delta \le 1$



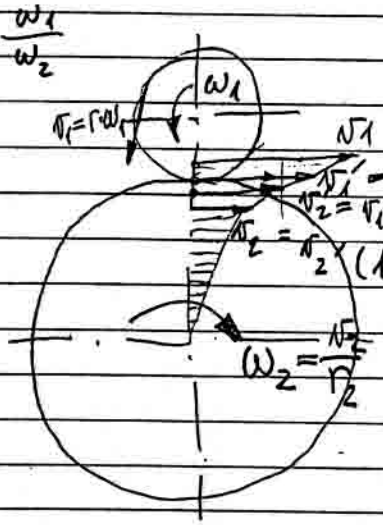


$R_f = f \cdot Q$

$f \rightarrow \frac{d}{r_{st}}$

$M_f = R_f \cdot r_{st}$

$i = \frac{\omega_1}{\omega_2}$



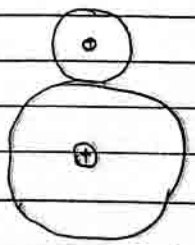
$\frac{\omega_1}{\omega_2} = i = \frac{v_1}{r_1}\cdot\frac{r_2}{v_2}$

$i = \frac{r_2}{r_1}\cdot\frac{1}{(1-\delta_1)(1-\delta_{zdr})(1-\delta_2)}$

$i \neq konst$

$i = f(M_t)$

i, P_1, n_1



$i = \frac{d_2}{d_1}\cdot\frac{1}{(1-\delta_1)(1-\delta_{zdr})(1-\delta_2)}$

$d_1 = \checkmark$

$d_2 = ?$ $\quad \delta_1, \delta_{zdr}\ \delta_2 = \checkmark$

μ vel, F_N majhn (δ_H majhn)

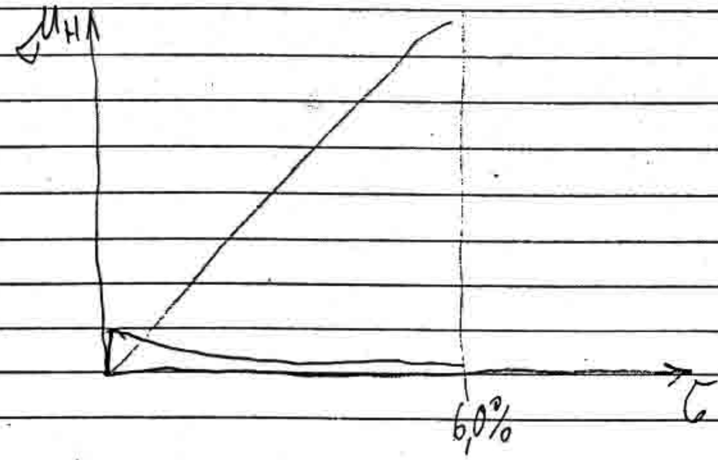
$\mu'_m \rightarrow (1{,}13)$ $\quad 0{,}9 \rightarrow 1{,}0$

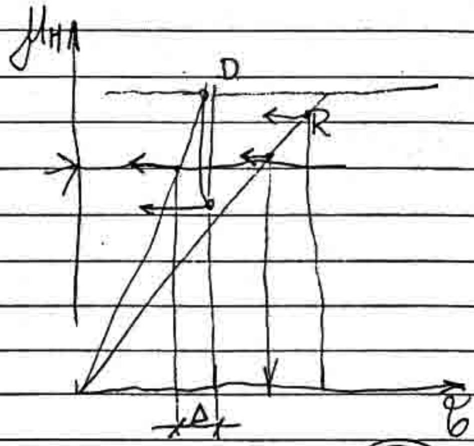
$\mu'_g \rightarrow$

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

I II III IV V VI VII VIII IX X XI XII

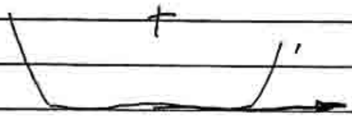
Predmet Mehek torn material dober
Trd nevaren





$M_{t_1} = ?$

$F_{t_1} = ?$



$F_{t1} \leq F_{tR}$

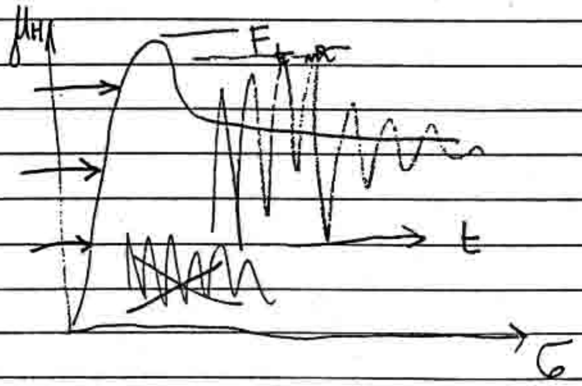
$F_N \cdot \mu'_m > F_{t1}$

$F_N \cdot \mu'_m = F_{t1} \cdot S$ (1→5)

$F_N = ?$

$\sigma_H = ?$ $f(F_N, b, \rho_n)$

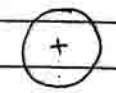
$\sigma_H \leq \sigma_{Hdop}$

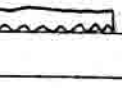


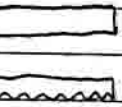
Predmet

Jermenska gonila

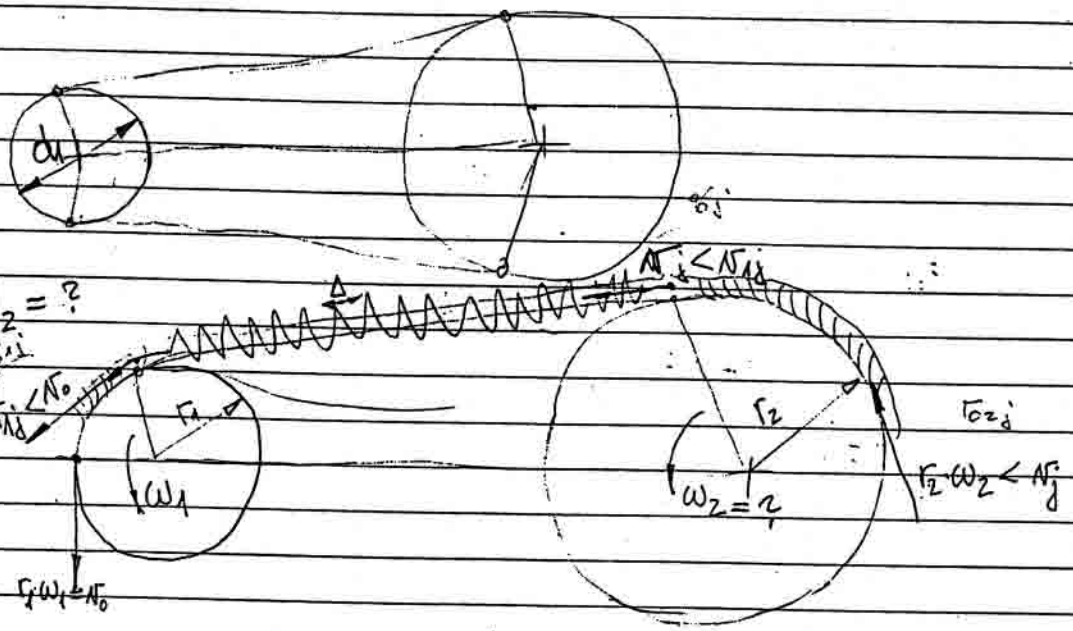
Če lovimo z vzamem. jermensko gonilo:







P_1, n_1, i, $\boxed{a}$



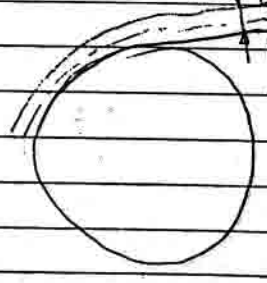
$$i = \frac{\omega_1}{\omega_2} = \frac{d_2}{d_1(1-\sigma_{1i})(1-\sigma_i)(1-\sigma_{2i})}$$

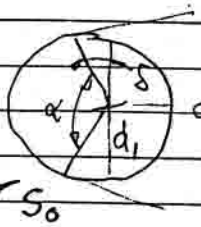
$\sigma_{1i} = 0.995$, σ_i elastični zdrs $= 0.98$, $\sigma_{2i} = 0.995$

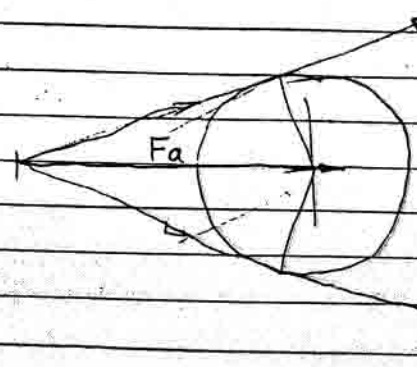
$d_2 = ?$

$a < d_1 d_2$

$L_i =$



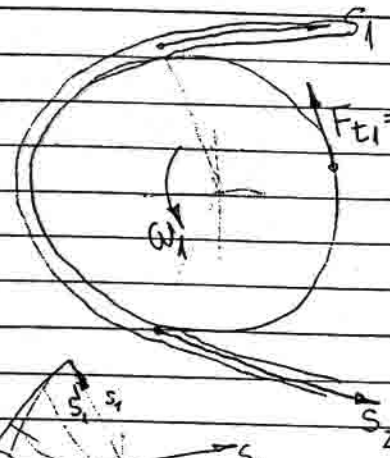




1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

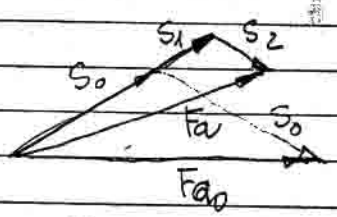
I II III IV V VI VII VIII IX X XI XII

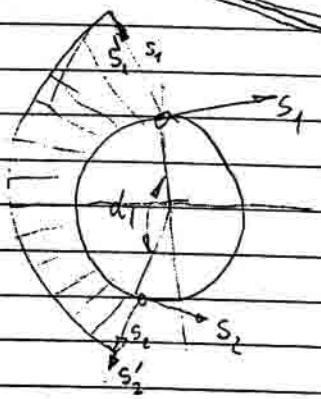
Predmet



$F_{t1} = \frac{2M_{t1}}{d_1}$

$S_1 - S_2 = F_{t1}$





$\frac{S_{1m}}{S_{2m}} = e^{\mu\alpha_1}$ ← mejno razmerje, ko se ni zdrsa

$S_{1m} - S_{2m} = F_{tR}$

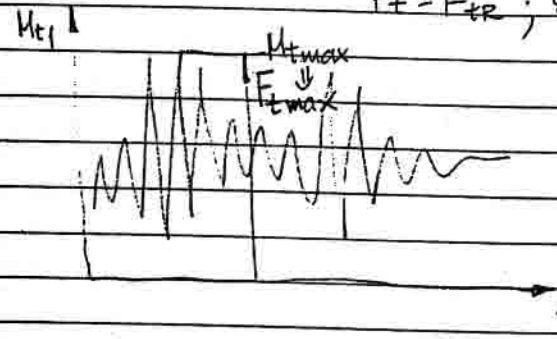
$F_t < F_{tR}$

$S_1 < S_{1m}$

$S_2 < S_{2m}$

$F_t = 0 \; ; \; S_1 = S_0 \; , \; S_2 = S_0$

$F_t = F_{tR} \; ; \; S_1 = S_{1m} \; , \; S_2 = S_{2m}$



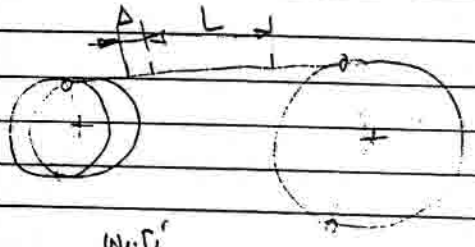
$S_1 - S_2 = F_{tmax}$

$\frac{S_1}{S_2} \equiv e^{\mu\alpha_1}$

$S_0 = \frac{S_1 + S_2}{2}$

$Fa_0 = ?$

$Fa = ?$

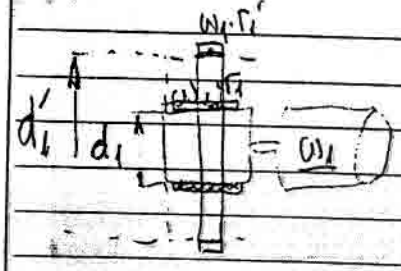


$\frac{\Delta}{L} = \varepsilon_j$

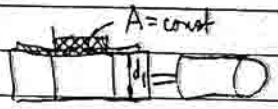
$\varepsilon_j = \frac{\sigma_j}{E_j}$

$\sigma_j = \frac{S_0}{A}$

$\Delta = ?$

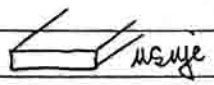


$P_{tg} = F_t \cdot v = P_1$



Predmet

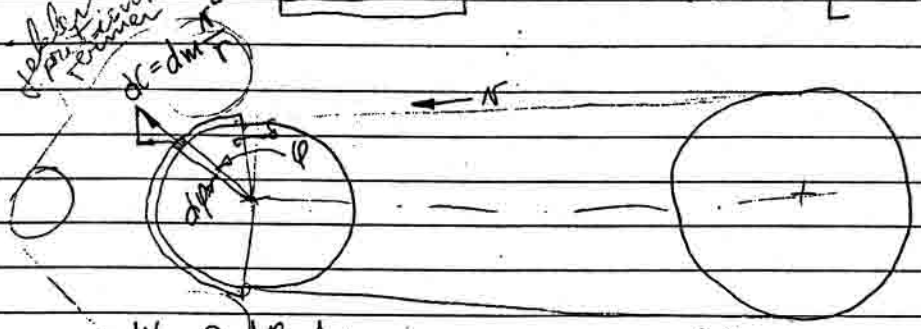
① KLASIČNA GRADNJA



$$S_1 + S_{dim} \leq S_{dop}$$

② MODERNA

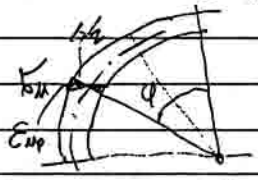
$$f_B = \frac{z \cdot N}{L} \leq f_{Bdop}$$



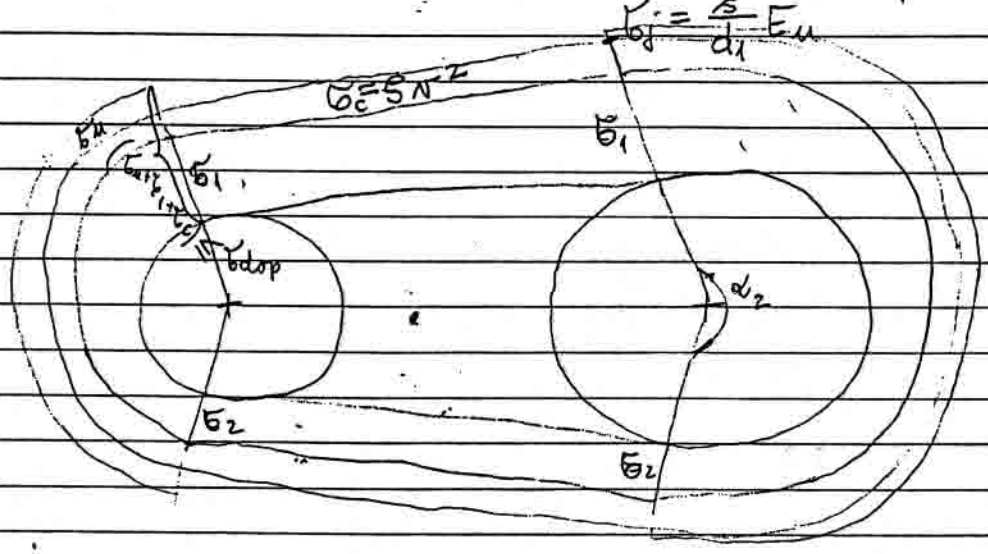
$$dV = r_1 d\varphi \cdot A_j$$
$$dm = dV \cdot \rho$$
$$dC = r_1 A_j \rho \frac{N^2}{r_1} d\varphi$$
$$dC' = dC \cdot \sin\delta$$

$$\int_{\delta}^{180^\circ - \delta} dC' = 2 A_j \rho N^2 \cos\delta$$

$$F_c = A_j \rho N^2 \rightarrow \sigma_{cj} = \rho N^2$$



$$\sigma_M = E_i \varepsilon_M$$
$$\frac{\varepsilon_M}{\delta/2} = \frac{\varphi(r_1 + \delta/2)}{r}$$

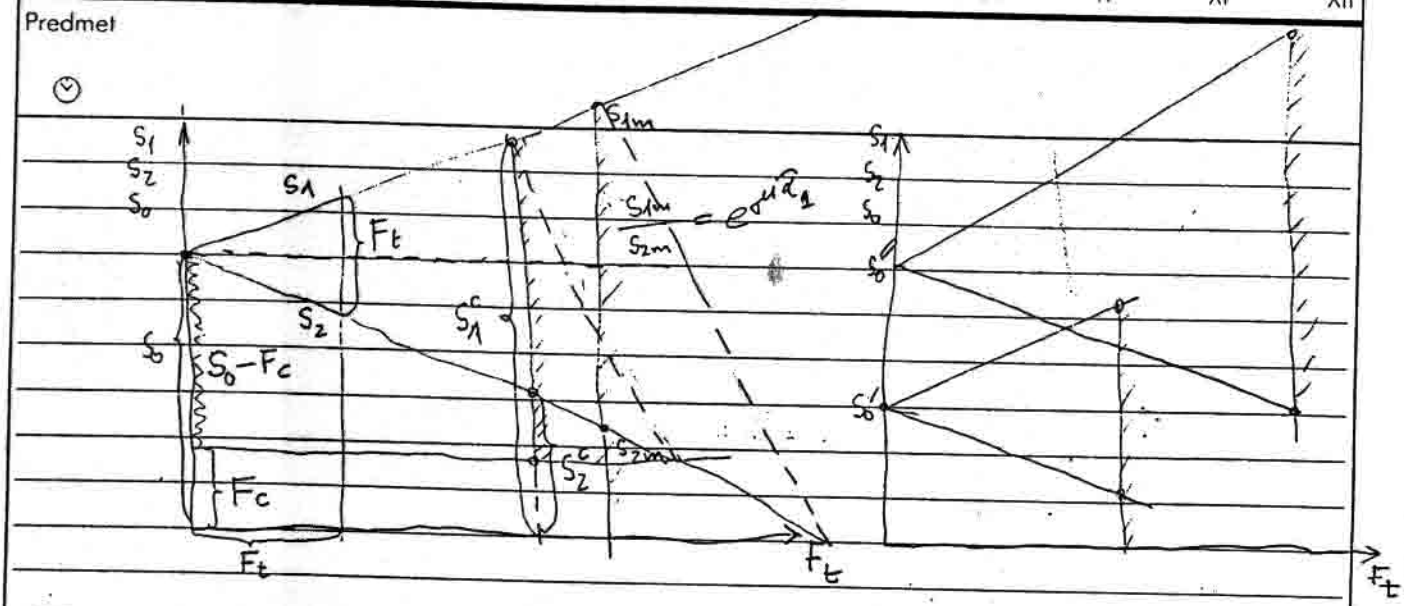


P_1, n_1, i
$d_1 \rightarrow n_1 \rightarrow N$
$d_2 = i \ldots$
$tip = ?$ $\quad \frac{t}{L} = \frac{d_1 \cdot C_1}{10}$
$tip \rightarrow P n_1$ $\quad$ (1cm) (F_L)

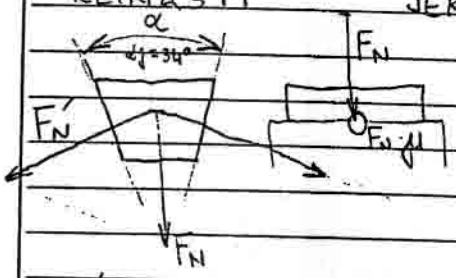
$$b = \frac{P_1}{P n_1} \frac{C_1 \cdot 10}{C_2}$$

$$f_B = \frac{zN}{L}$$

Predmet



KLINASTI JERMENI



$$F_{tR}' = F_N' \cdot 2 \cdot \mu$$

$$F_N' = \frac{F_N}{2 \cdot \sin \alpha/2}$$

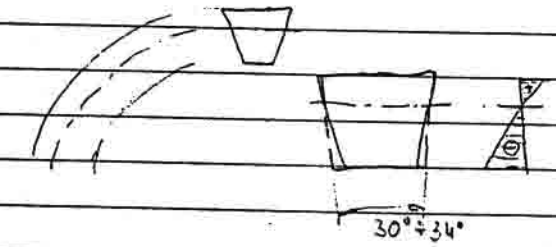
$$F_{tR}' = F_N \left(\frac{\mu}{\sin \alpha/2} \right)$$

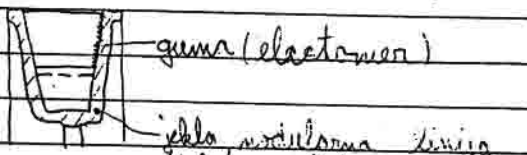
$$\mu' = \frac{\mu}{\sin \alpha/2}$$

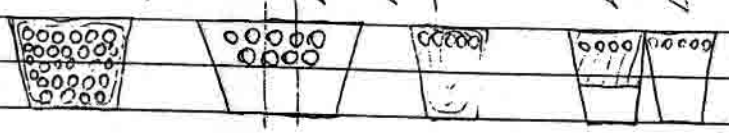
Manjše sile napenjanja
Možnost spremenljivega prestavnega razmerja

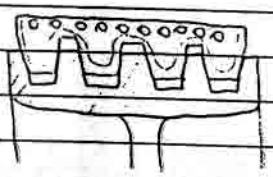
$$\frac{S_1}{S_2} = e^{\mu(\alpha_1)}$$

$$S_1 - S_2 = F_t$$









$$f_B = !!!$$

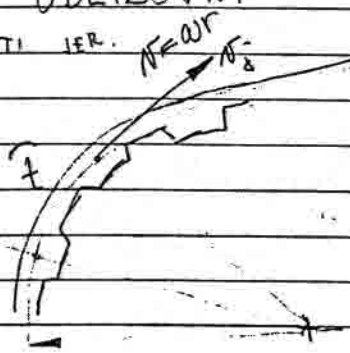
$$d_1 (P_N, i, n_1)$$

$$(d_2 = i d_1 / \dots)$$

Predmet

OBLIKOVNI PRENOS

ZOBATI JER.

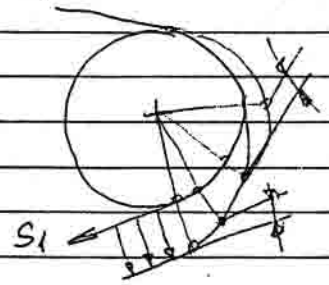


$v_1 = \omega_1 r_{o1} = v_2 = \omega_2 r_{o2}$

$\frac{\omega_1}{\omega_2} = i = \frac{r_{o2}}{r_{o1}} = \frac{z_2}{z_1}$

$t \cdot z_1 = \pi d_{o1}$

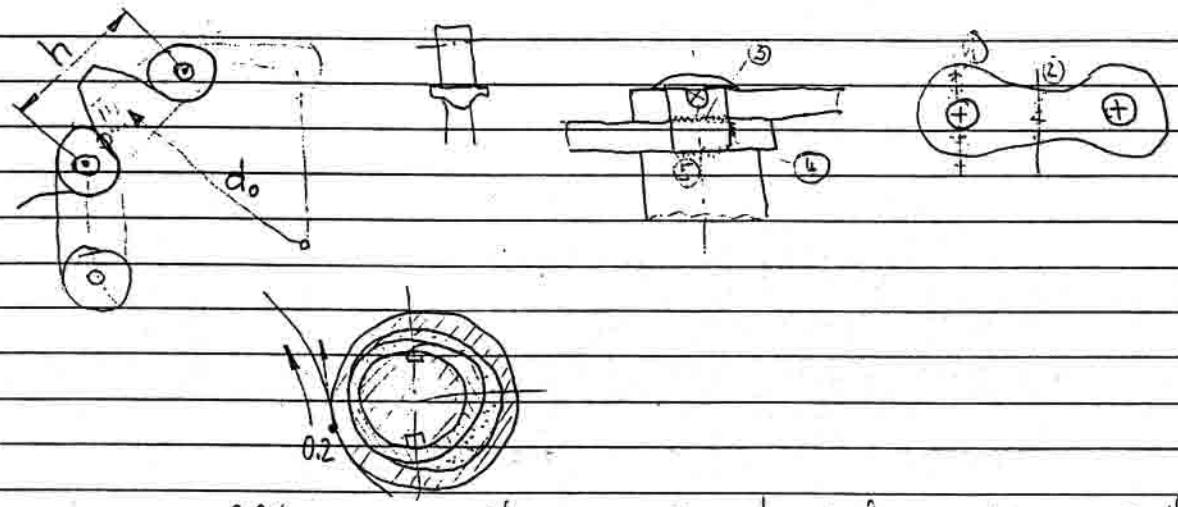
$i = \frac{z_2}{z_1}$



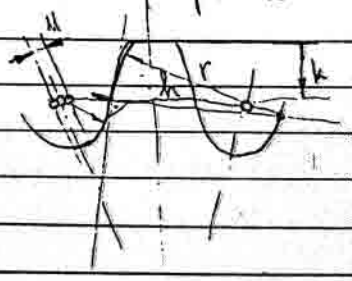
Medosna razdalja je določena

$P_1 = F_t \cdot v$

VERIŽNI PRENOS

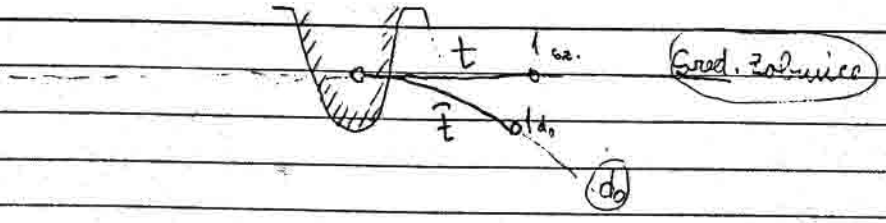


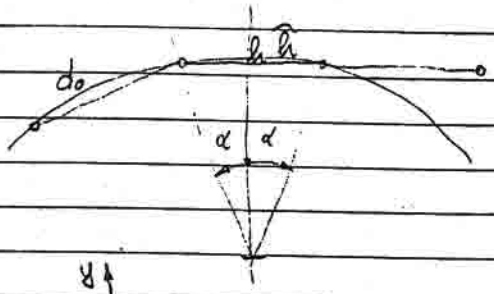
STANDARDNA oblika upošteva značnost, deformacijo verižnikov in verige.



Predmet

$t = \bar{t}$





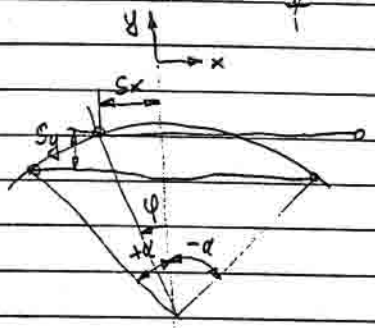
$\pi d_0 = z \cdot \hat{h}$

$\alpha = \frac{180}{z}$

$\hat{h} = r_0 \cdot 2\alpha$

$\frac{h}{2} = r_0 \cdot \sin\alpha$

$h = d_0 \cdot \sin\alpha$



$\varphi = \omega t$

$s_x = \frac{d_0}{2} \sin\varphi$

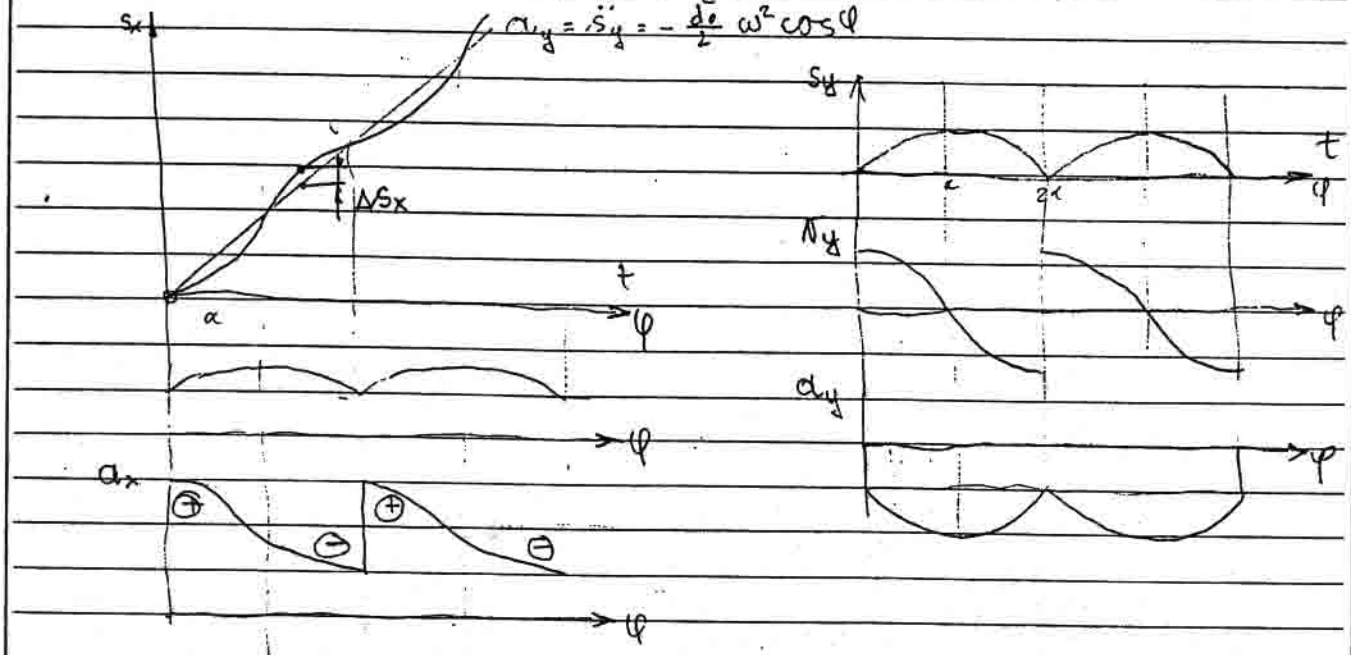
$s_y = \frac{d_0}{2}(\cos\varphi - \cos\alpha)$

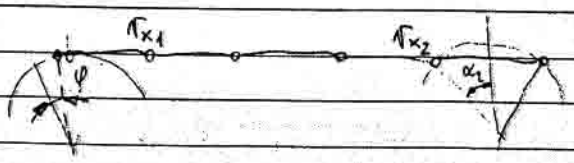
$v_x = \dot{s}_x = \frac{d_0}{2} \omega \cos\varphi$

$v_y = \dot{s}_y = -\frac{d_0}{2} \omega \sin\varphi$

$a_x = \dot{s}_x = -\frac{d_0}{2} \omega^2 \sin\varphi$

$a_y = \dot{s}_y = -\frac{d_0}{2} \omega^2 \cos\varphi$





$\Delta v_{x1} = \Delta v_{x2}$

$d_{01} = \frac{h}{2 \cdot \sin\alpha_1}$

$d_{02} = \frac{h}{2 \cdot \sin\alpha_2}$

$i = \frac{\omega_1}{\omega_2} = \frac{\cos\varphi_2}{\sin\alpha_2} \cdot \frac{\cos\varphi_1}{\sin\alpha_1}$

Predmet

$\varphi_1 = \alpha_1 \quad \varphi_2 = \alpha_2 \qquad \varphi_1 = 0 \;,\; \varphi_2 = 0$

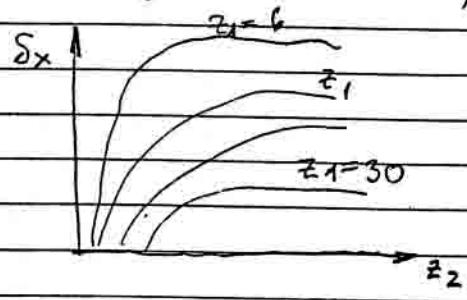
$i = \frac{\tan\alpha_1}{\tan\alpha_2} \qquad i = \frac{\sin\alpha_1}{\sin\alpha_2}$

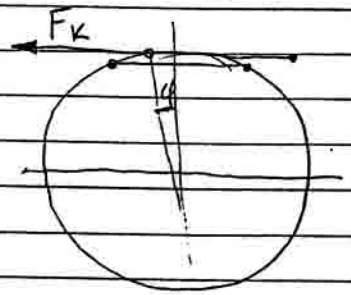
$\varphi_1 = 0 \qquad \varphi_2 = \alpha_2$

$i = \frac{\sin\alpha_1}{\tan\alpha_2}$

$\delta = \frac{\omega_{2max} - \omega_{2min}}{\omega_{sr}} \qquad \delta = 2\,\frac{1 - \frac{\sin\alpha_2 \tan\alpha_1}{\sin\alpha_1 \tan\alpha_2}}{1 + \frac{\sin\alpha_2 \tan\alpha_1}{\sin\alpha_1 \tan\alpha_2}}$

$\omega_{sr} = \frac{1}{\delta}(\omega_{2max} - \omega_{2min}) \qquad L_{NE} = S_M \cdot z$



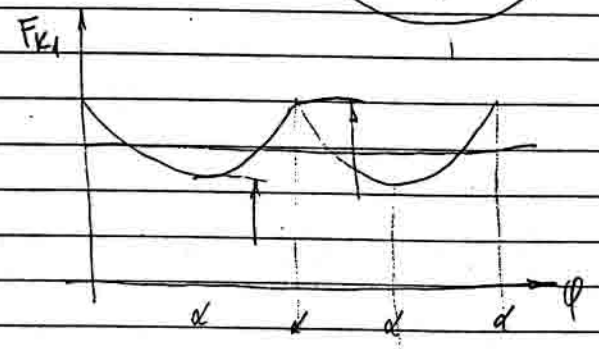


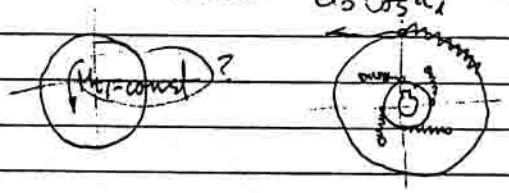
$F_K = \frac{2M_{t1}}{d_{01}\cos\varphi}$

$M_{t1} = const$

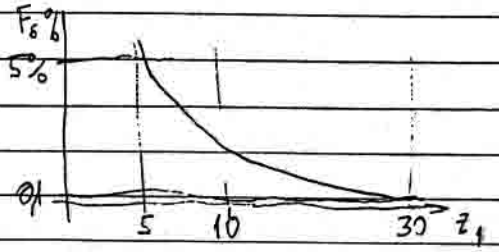
$F_{Kmin} = \frac{2M_{t1}}{d_{01}}$

$F_{Kmax} = \frac{2M_{t1}}{d_0 \cos\alpha_1}$





$F_\delta = \frac{F_{SR} - F_{MIN}}{F_{SR}}$

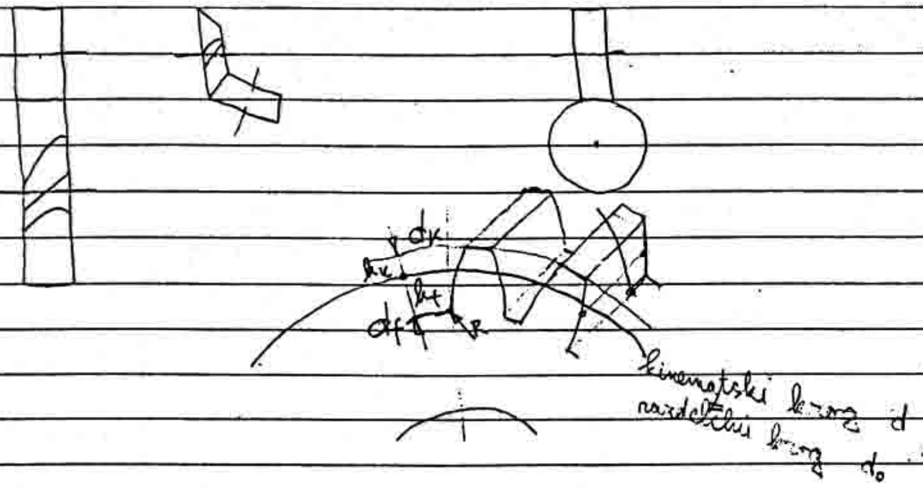


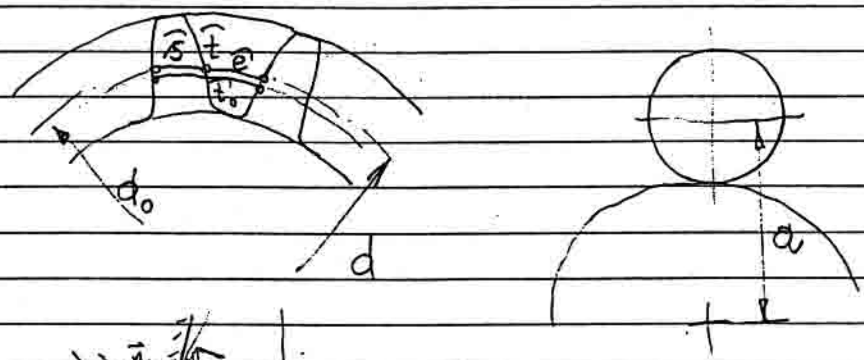
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

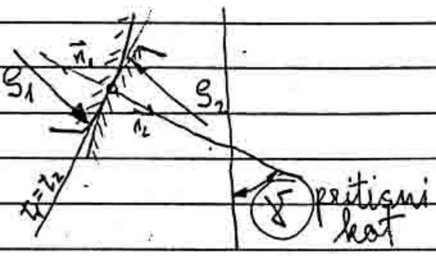
I II III IV V VI VII VIII IX X XI XII

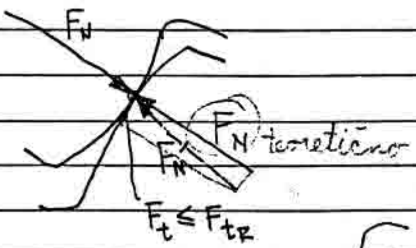
Predmet

ZOBNIŠKA GONILA



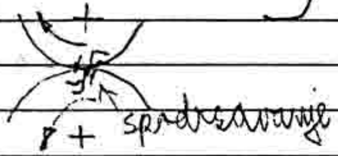


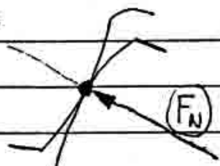




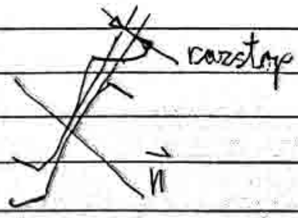
$F_{tR} = \mu \cdot F_N$

μ majhen (0,05)



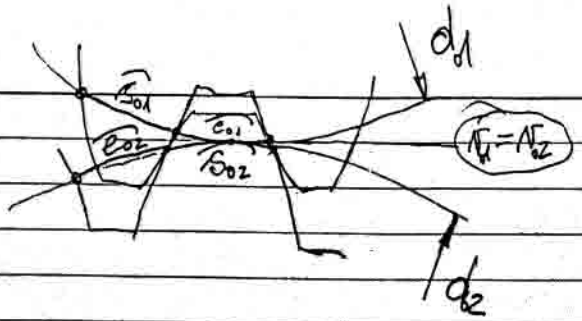


Če izzovemo podrsavanje lahko F_N prenašamo samo v smeri normale.



Predmet

USIO



$\widehat{t_{o1}} = \widehat{s_{o1}} + \widehat{e_{o1}}$

$\widehat{t_{o2}} = \widehat{s_{o2}} + \widehat{e_{o2}}$

$\widehat{t_{o1}} = \widehat{t_{o2}} = \widehat{t_o}$

$\widehat{s_{o2}} \leq \widehat{e_{o1}}$

$\frac{s_o}{d_1} = \frac{1}{2} t_o$; $c_o = \frac{1}{2} t_o \Rightarrow e_{o2}, s_{o2}$

$N_1 = r_1 \cdot \omega_1$

$N_1 = N_2$

$N_2 = r_2 \cdot \omega_2$

$a = r_1 + r_2$

$i = \frac{\omega_1}{\omega_2} = \frac{r_2}{r_1}$

$\pi d_1 = z_1 \widehat{t_o}$

$\pi d_2 = z_2 \widehat{t_o}$

$\frac{d_2}{d_1} = \frac{r_2}{r_1} = \frac{z_2}{z_1}$

$i = \frac{z_1}{z_2}$

$z_1, z_2 \in \{N\}$

d_1 = okrogla (standardna) številka

$d_1 = z_1 \frac{t_o}{\pi}$ } m približno cela

$d_2 = z_2 \frac{t_o}{\pi}$ } m

$m = \frac{t_o}{\pi}$

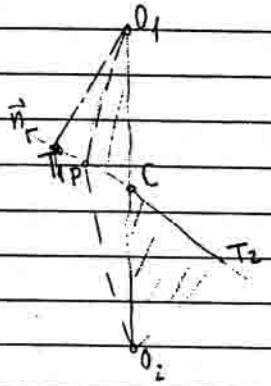
$m\pi = t_o$

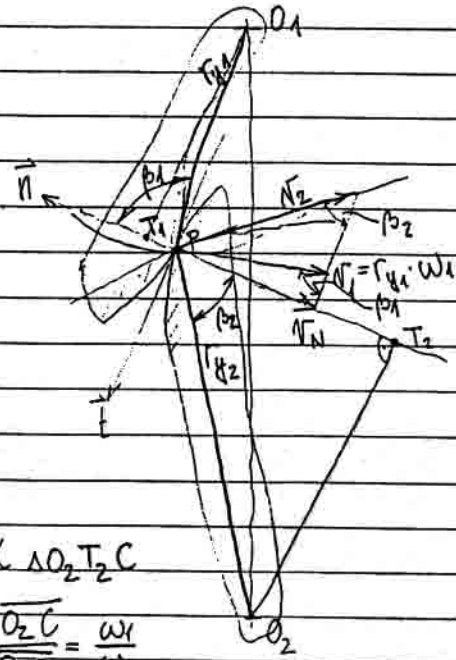
ZAKON OZOBJA

$\omega_1 = \text{const}$

$i = \frac{\omega_1}{\omega_2} = \text{const}$

$\omega_2 = \text{const} \neq f(t)$





$N_N = N_1 \cdot \sin\beta_1$

$N_N = N_2 \cdot \sin\beta_2$

$N_1 = r_{y1} \cdot \omega_1$

$N_2 = r_{y2} \cdot \omega_2$

$\frac{\omega_1}{\omega_2} = \frac{r_{y2} \cdot \sin\beta_2}{r_{y1} \cdot \sin\beta_1} = \text{const}$

$r_{y2} \cdot \sin\beta_2 = \overline{O_2 T_2}$

$r_{y1} \cdot \sin\beta_1 = \overline{O_1 T_1}$

$\frac{\omega_1}{\omega_2} = \frac{\overline{O_2 T_2}}{\overline{O_1 T_1}}$

$\Delta O_1 T_1 C \sim \Delta O_2 T_2 C$

$\frac{\overline{O_2 T_2}}{\overline{O_1 T_2}} = \frac{\overline{O_2 C}}{\overline{O_1 C}} = \frac{\omega_1}{\omega_2}$

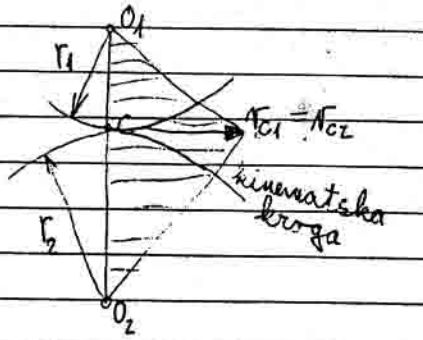
$\overline{O_1 C} + \overline{O_2 C} = K = a$

$\overline{O_1 C} + \overline{O_2 C} = a$

$\frac{\overline{O_2 C}}{\overline{O_1 C}} = i$

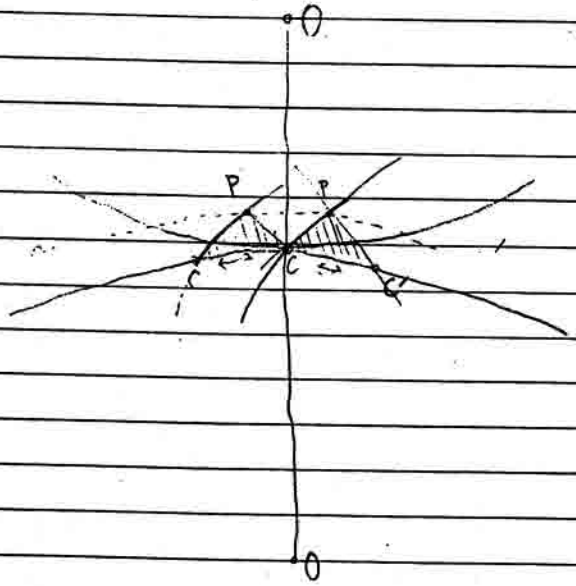
Predmet

$\frac{O_2C}{O_1C} = (k = i = \frac{\omega_1}{\omega_2}) = \frac{r_2}{r_1} = i$



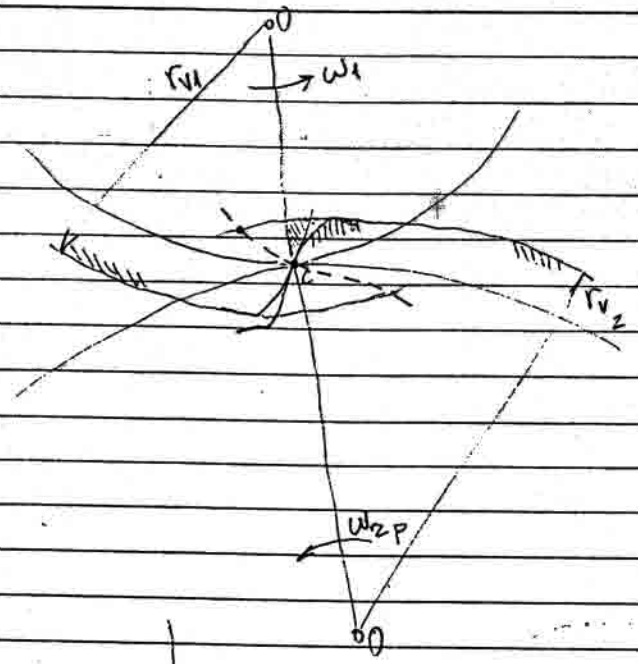
$v_{c1} = r_1 \omega_1$
$v_{c2} = r_2 \cdot \omega_2$
$v_{c1} = v_{c2}$
$\frac{\omega_1}{\omega_2} = \frac{r_2}{r_1}$

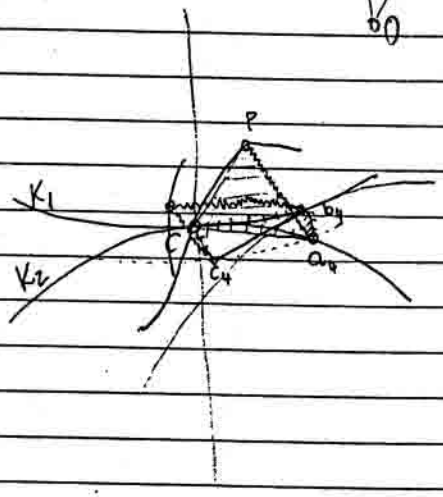
Zakon ozobja pravi, da če hočemo imeti ves čas enakomeren (nespremenljiv) prenos vrtilnega gibanja pri $i = const$ ves čas, mora normala iti na bok zoba v dotiku na vsakokratni bok zoba iti skozi točko C, ki je kinematski pol, saj se v njej dotikata oba kinematska kroga, ki se odkataljujeta.

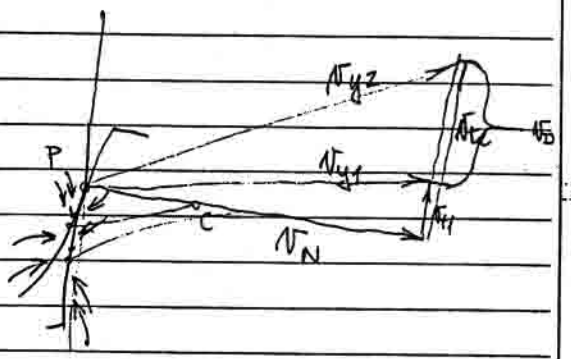


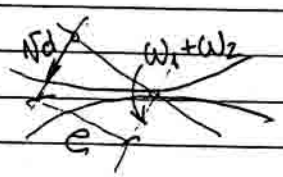
Sl. 19.1

Predmet





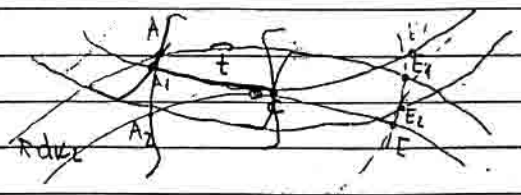




$v_d = e(\omega_1+\omega_2)$

SLIKA 24.1 (? OBRAZNA DOLŽINA ZOBA)

Predmet



$\widehat{t} < \widehat{A_1CE}$

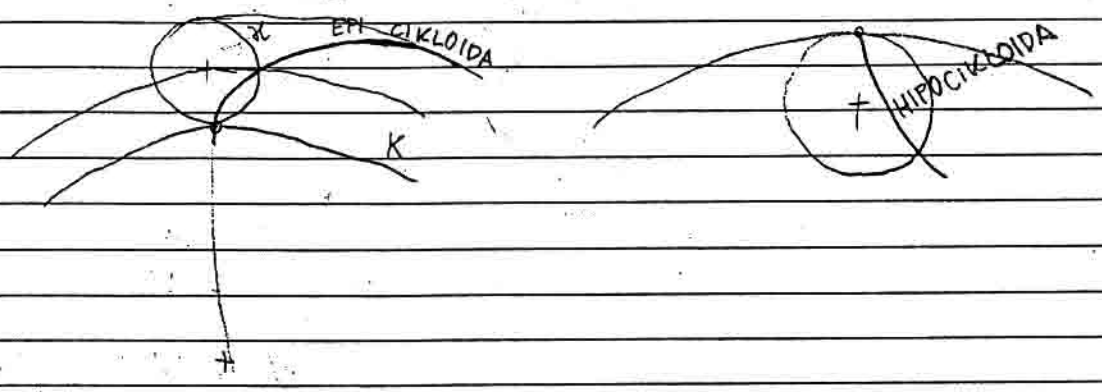
$\varepsilon_\alpha = \frac{\widehat{A_1CE}}{\widehat{t}}$

$\varepsilon_\alpha \geq 1{,}2$

$\widehat{A_1CE_1} = \widehat{A_2CE_2}$

$\widehat{A_1C} - \widehat{A_2C}$

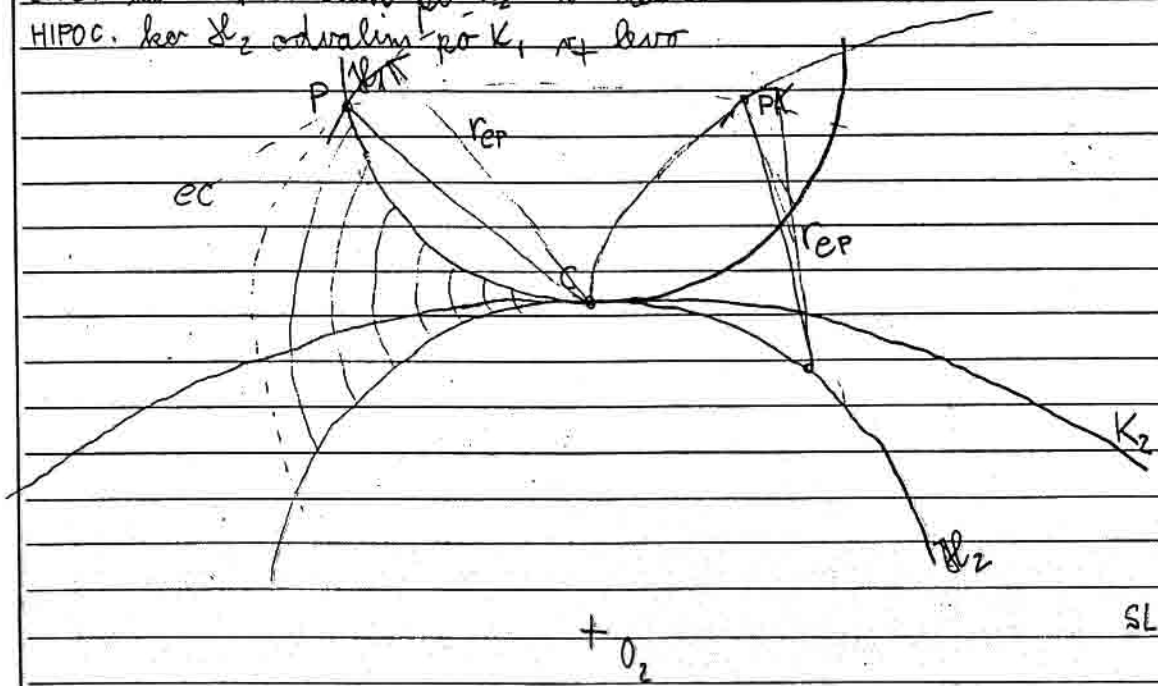
CIKLOIDNI ZOBNIKI



SL. 36.1

EPIC. ko $\mathcal{Z}_1$ odvalim po K_2 v desno

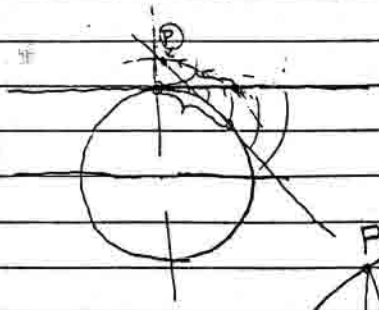
HIPOC. ko $\mathcal{Z}_2$ odvalim po K_1 v levo

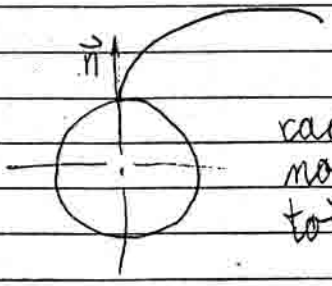


SL. 36.1

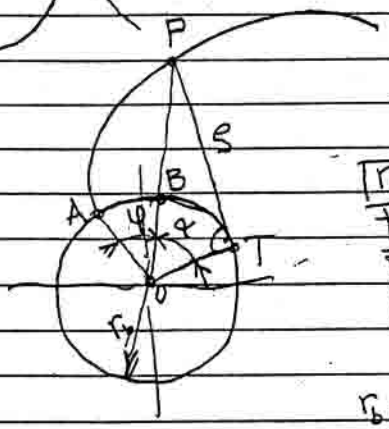
Predmet

EVOLVENTNI ZOBJE





radij ukrivljenosti v začetni točki je 0.



r_b osnova

$\tan\alpha = \frac{S}{r_b}$

$\overline{PT} \equiv S \equiv \widehat{AT}$

$\widehat{AT} = r_b \cdot (\varphi + \alpha_{r_b})$

$r_b \neq \checkmark$

P na evolventi ?

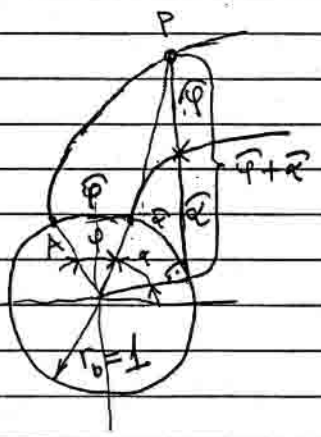
1. $r_b = \checkmark$, α
2. $r_b = \checkmark$, $\overline{OBP}$
3. $\varphi \rightarrow \sphericalangle$, $\overline{OA}$ in $\overline{OP}$

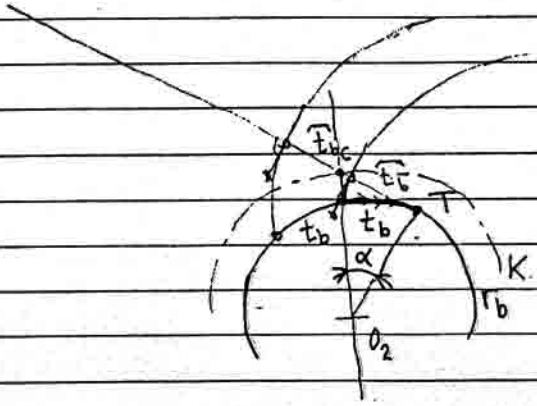
$\widehat{AB}$ $\varphi = \frac{\overline{AB}}{r_b}$

$r_b \cdot \tan\alpha = \overline{PT} = \widehat{AT} = (\varphi + \alpha) \cdot r_b$

$\varphi = \underbrace{\tan\alpha - \alpha}_{ev\,\alpha}$

$r_b = \checkmark$, $ev\,\alpha$





$t_b = \frac{\pi d_b}{z}$

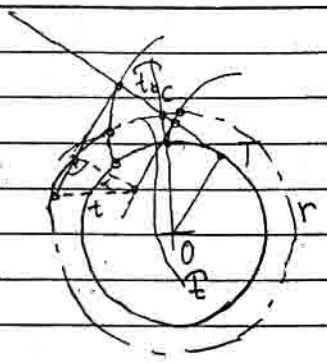
$t_b = \widehat{\alpha} \cdot r_b$

K (kotalni krog je določen z r_b in α)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

I II III IV V VI VII VIII IX X XI XII

Predmet



$$t = \frac{t_B}{\cos\alpha}$$

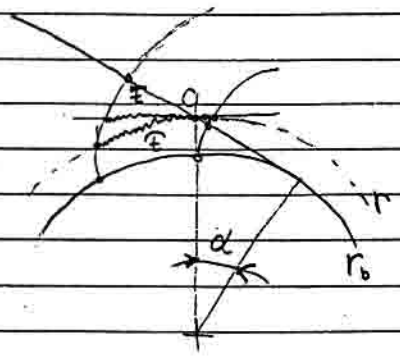
$$\triangle CTO \rightarrow r = \frac{r_b}{\cos\alpha}$$

$$t = \frac{\pi r}{z}$$

$$t_b = \frac{\pi r_b}{z}$$

$$\frac{t_b}{t} = \cos\alpha$$

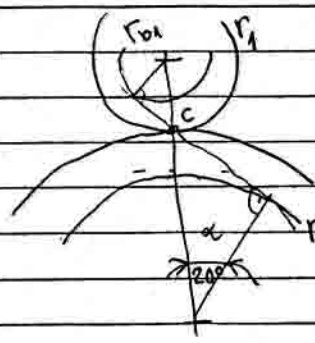
$$\frac{t_b}{t} = \frac{r_b}{r}$$



SL. 49.1

SL. 51.1

Predmet



$\pi r_1 = z_1 \cdot t$

$\pi r_2 = z_2 \cdot t$

$i = \frac{z_2}{z_1}$

$r_1 = z_1 \frac{t}{\pi}$

$r_2 = z_2 \frac{t}{\pi}$

$a = (z_1 + z_2)\frac{m}{2}$

$m\pi = t$

$t = m\pi$ → iz R40

α izberem (20°)

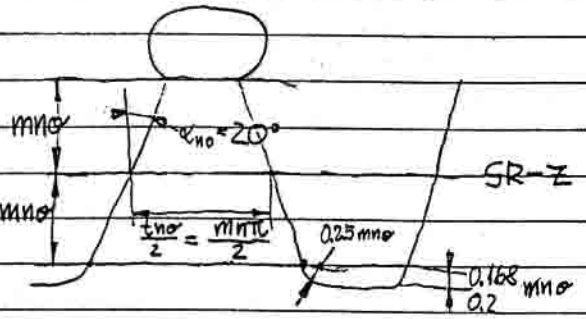
$\alpha_{\text{ORODJA}} = 20°$ NORMALNI ZOB

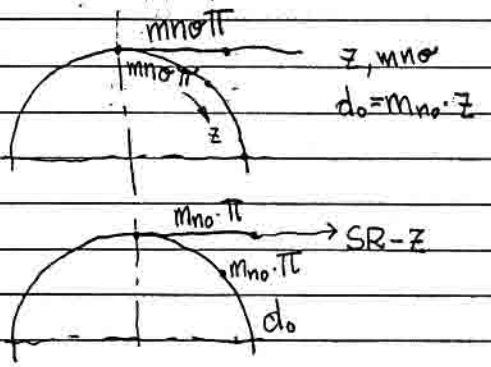
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

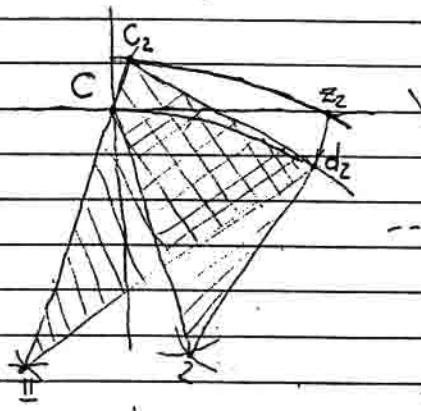
I II III IV V VI VII VIII IX X XI XII

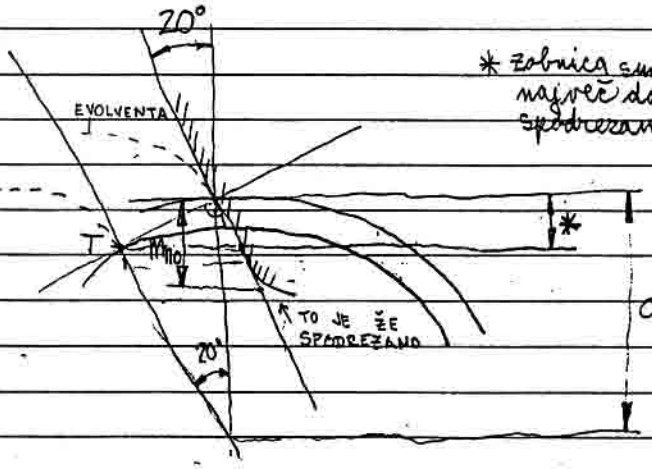
Predmet

STANDARDNA ZOBNICA

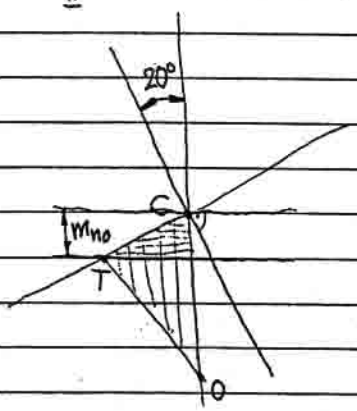








* zobnica sme segati največ do "T" če želimo spodrezanega zoba



$\overline{CT} = \overline{CO} \cdot \sin \alpha_{no} \quad - \Delta(TCO)$

$m_{no} = \overline{CT} \cdot \sin \alpha_{no}$

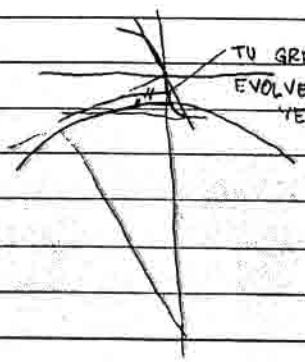
$\overline{CO} = \frac{\overline{CT}}{\sin \alpha_{no}} = \frac{m_{no}}{\sin^2 \alpha_{no}}$

$\frac{m_{no} \cdot z_{mej}}{2} = \frac{m_{no}}{\sin^2 \alpha_{no}}$

$z_{mej} = \frac{2}{\sin^2 \alpha_{no}} = 17$ (mejno število zob, da še ni spodrezanja)

$z^P_{mej} = 14$ (praktično mejno število zob, da še ni spodrezanja)

(IZPIT) (mejno št. zob)

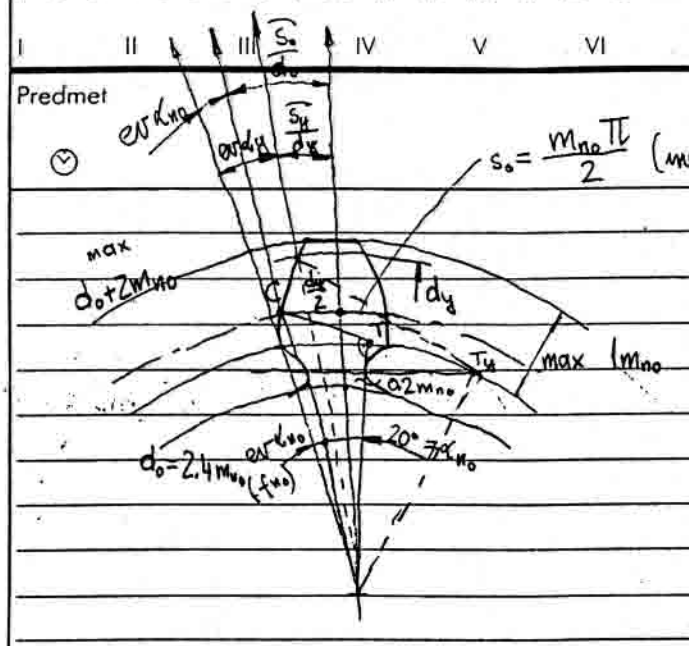


- ubirnica je tvornica evolvente

Predmet

$s_0 = \frac{m_{n0}\pi}{2}$ (mera po loku)

SLIKA 53.1



$\Delta CTO \Rightarrow \frac{d_r}{2} = \frac{d_0}{2} \cdot \cos\alpha_{n0}$ (zunanji)

$\Delta PTO \Rightarrow \frac{d_0}{2} = \frac{d_y}{2} \cdot \cos\alpha_y$

$\frac{d_0}{d_y} = \frac{\cos\alpha_{n0}}{\cos\alpha_y}$

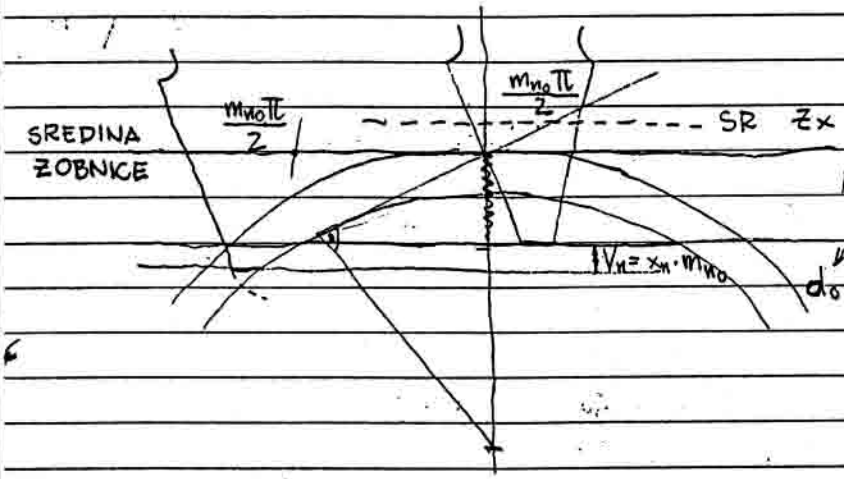
$\cos\alpha_y = ?$

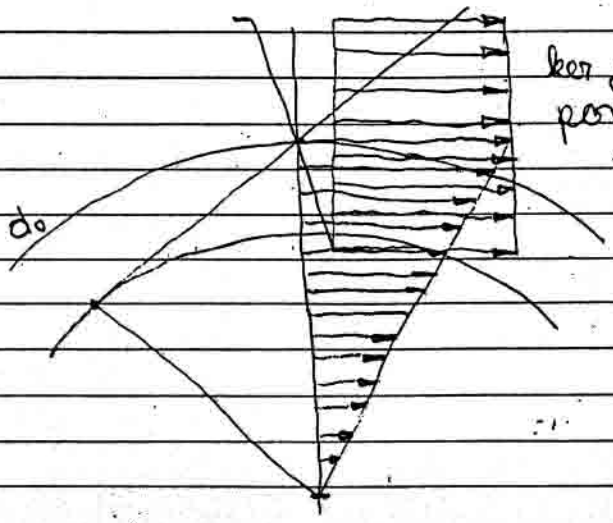
$\alpha_y = ?$

$s_y = ?$

$s_0 = m_{n0}, \alpha_{n0}, z$

$\frac{s_y}{d_y} + \text{ev}\,\alpha_y = \frac{s_0}{d_0} + \text{ev}\,\alpha_{n0}$





ker je translatorno gibanje in je potrebno enako.

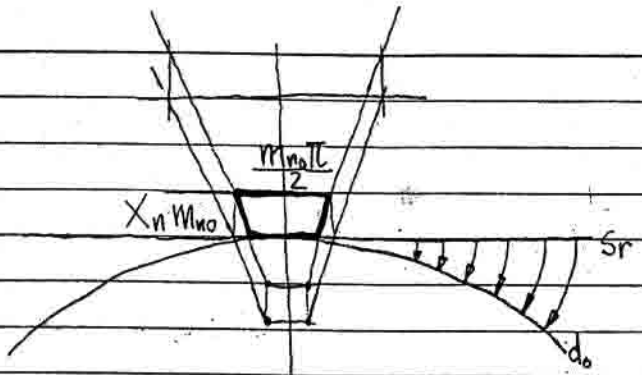
$(1 - X_n) m_{n0} = CT \cdot \sin\alpha_{n0}$

$CT = \frac{m_{n0} \cdot z}{2} \cdot \sin\alpha_{n0}$

$X_n = \frac{z_{min} - z}{z_{min}}$

$X_n = \frac{14 - z}{17}$

Predmet



Sl. 63.1

$e_o = \frac{m_n \cdot \pi}{2} - 2X_n m_{no} \cdot \tan \alpha_{no}$

$s_o = \frac{m_n \pi}{2} + 2\alpha_n m_{no} \cdot \tan \alpha_{no}$

korekcija ni pravi izraz

$\frac{m_{no}\pi}{2}$, $\frac{m_{no}\pi}{2} + 2X_n \cdot m_n \cdot tg\, \alpha_o$

$\frac{s_y}{d_y} + ev\, \alpha_y = \frac{s_o}{L_o} + ev\, \alpha_o$

$d_y = ?$, kje je $s_y = 0$?

$s_y = d_y \cdot \frac{s_o}{d_o} + (ev\, \alpha_{no} - ev\, \alpha_y)$

$s_y = 0$

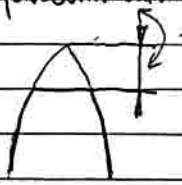
$\frac{s_o}{d_o} + ev\, \alpha_{no} - ev\, \alpha_y = 0$

$ev\, \alpha_y = ?$

$ev\, \alpha_y = \tan \alpha_y - \widehat{\alpha_y}$

$\alpha_y = ?$

pustimo samo 0.25m



$d_y \cdot \cos \widehat{\alpha_y} = d_b$

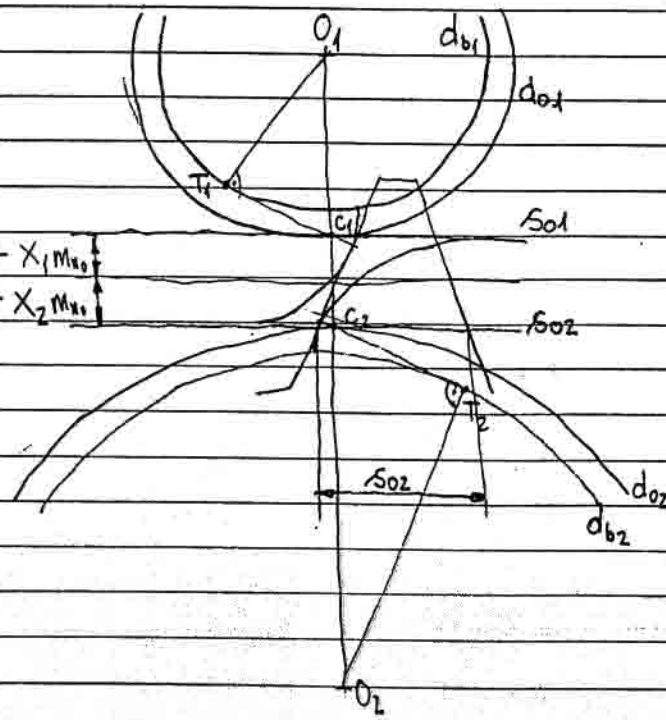
$= d_o \cos \alpha_{no}$

$d_y = ?$

$\frac{s_y}{d_y} + ev\, \alpha_y = \frac{s_o}{d_o} + ev\, \alpha_{no}$

$\frac{s_b}{d_b} + 0 = \frac{s_o}{d_o} + ev\, \alpha_{no}$

$s_b = znan$



$a_o' = \frac{d_{o1}}{2} + \frac{d_{o2}}{2} + m_{no} \cdot X_1 + m_{no} \cdot X_2$

$a = a_o' - s_k$

$k \cdot m_{no}$

$a_o = \frac{d_{o1} + d_{o2}}{2}$ (če nista korigirana)

$i = \frac{d_{o1}}{d_{o2}} = \frac{d_2}{d_1} \rightarrow C$ (zakon ozobja)

Sl. 81.1

Predmet

$\widehat{s_1} = \widehat{e_2}$

$\widehat{e_1} = \widehat{s_2}$

$\widehat{s_1} + \widehat{e_1} = \widehat{t_1} = \frac{\pi d_1}{z_1}$

$\widehat{s_2} + \widehat{e_2} = \widehat{t_2} = \widehat{t_1} = \frac{\pi d_2}{z_2}$

$z_1 = i z_2$

$d_{o1} = m_{no} \cdot z_1 \quad ; \quad d_{o2} = d_{o1} \cdot \cos\alpha_n$

$ev\,\alpha = 2\frac{x_{n1} + x_{n2}}{z_1 + z_2} \cdot \tan\alpha_{no} + ev\,\alpha_{no}$

$d_1 = \frac{d_{b1}}{\cos\alpha} = \frac{d_{o1} \cdot \cos\alpha_{no}}{\cos\alpha}$

$d_2 = \frac{d_{b2}}{\cos\alpha} = \frac{d_{o2} \cdot \cos\alpha_{no}}{\cos\alpha}$

$s_1 = d_1\left[\frac{s_{o1}}{d_{o1}} + ev\,\alpha_{no} - ev\,\alpha\right]$

$s_2 = d_2\left[\frac{s_{o2}}{d_{o2}} + ev\,\alpha_{no} - ev\,\alpha\right]$

$s_{o1} = \frac{m_{no}\pi}{2} + 2x_{n1} + m_{no} \cdot \tan\alpha_{ono}$

$s_{o2} = \frac{m_{no}\pi}{2} + 2x_{n2} + m_{no} \cdot \tan\alpha_{ono}$

$\left.\begin{matrix} d_1 \\ d_2 \end{matrix}\right\} = ?$

$a = \frac{d_1 + d_2}{2}$

$s_k = a_o' - a$

1. ZOBNIK
- $d_{f1} = d_{o1} \simeq 2{,}4\, m_{no} + 2x_{n1} \cdot m_{no}$ ↔ temenski krog
- $d_{k1} = d_{o1} + 2m_{no} + 2x_{n1} \cdot m_{no} - 2s_k$ ↔ glavni krog

2. ZOBNIK

pri + korekciji zobje ukrivajo pod večjim kotom, zobje so močnejši (v korenu) šiljast zob, stopnja prekritja se zmanjša, medosna razdalja se poveča je krajša (+ ↔ poveča ; − ↔ zmanjša)

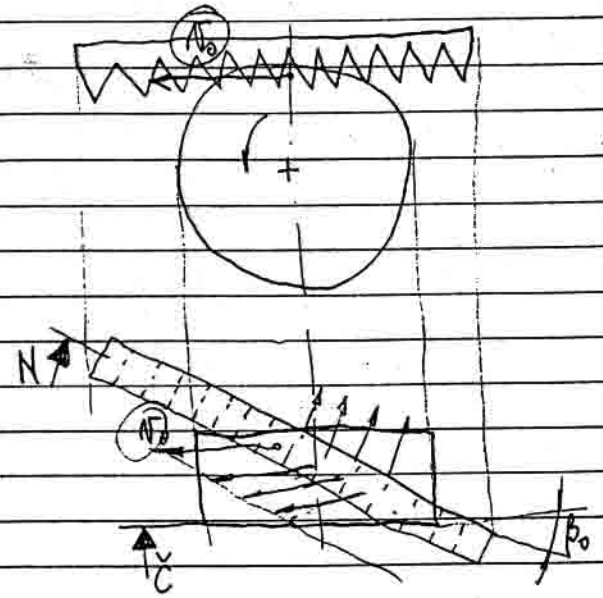
Sl. 69.1

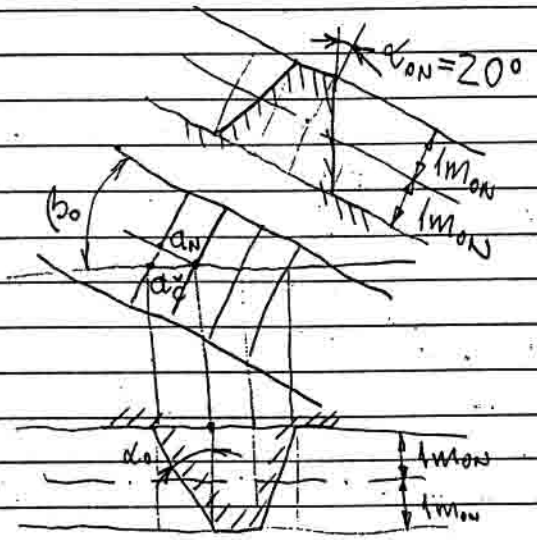
	x	debelina korena	ε_α	α	namen
enojna + korekc.	$+x_1$	s_1+	−	+	več nosi, + a
enojna − korekc.	$-x_2$	s_2-	+	−	$+\varepsilon_\alpha$ povečan, − a
d ± korekcija	$+x_1$	s_1+	~	~	a in ε_α kvišku
	$-x_2$	s_2-			
VO ±	$+x_1 = -x_2$	$+s_1 - s_2$	ni spremembe	−	močnejši 1. zobnik kvišku z_{min}

Predmet

POŠEVNO OZOBJE

Sl. 93.1





$a_N = a_{\check{C}} \cdot \cos\beta_0$

$\tan\alpha_{0N} = \tan 20°$

$\tan\alpha = \tan\alpha_{\check{C}} = \frac{a_{\check{C}}}{2m_{0N}}$

$\tan 20° = \frac{a_N}{2m_{0N}}$

$\tan\alpha = \frac{\tan\alpha_{0N}}{\cos\beta_0}$

$t_0 = \frac{t_{0N}}{\cos\beta_0}$

$m_0 \cdot \pi = \frac{m_{0N}\,\pi}{\cos\beta_0}$

$m_0 = \frac{m_{0N}}{\cos\beta_0}$

z ✓ m_{0N}

$\alpha_{0N} = 20°$

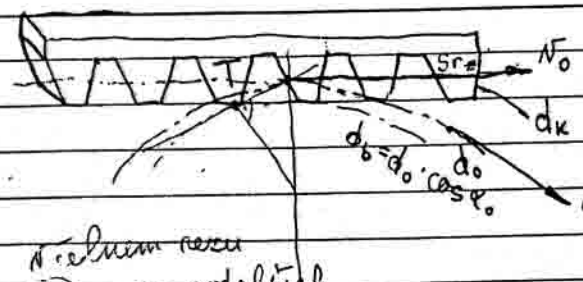
β_0 ✓

$m_0 = \frac{m_{0N}}{\cos\beta_0}$

$d_0 = m_0 \cdot z$

$d_k = d_0 + 2m_{0N}$

Predmet



N. celum rezu

$\varepsilon = \varepsilon_\alpha + \varepsilon_\beta$ podaljšek vbirnice zaradi poševnosti

$\varepsilon_\beta = \frac{\overline{1''2''}}{t_b}$

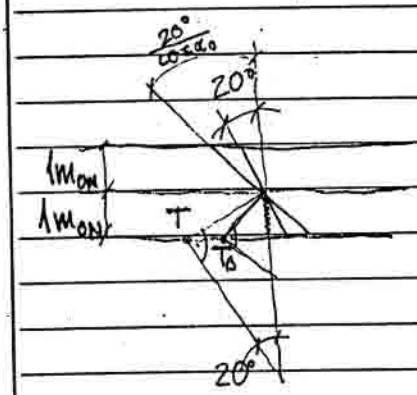
sl. 99.1

$\overline{1''2''} = ?$

$\overline{1''2''} = (1''3'')\cos\alpha_0$

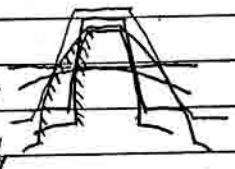
$\Delta 3'T'1' \rightarrow \overline{1'3'} \equiv \overline{1''3''} = b \cdot \tan\beta_0$

$\varepsilon_\beta = \frac{b \cdot \tan\beta_0 \cdot \cos\alpha_0}{t_b}$



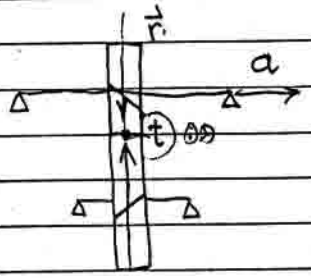
Minimalno število zob je manjše

$z_\beta = z \cdot \cos^2\beta_0 \cdot \cos\beta_b$



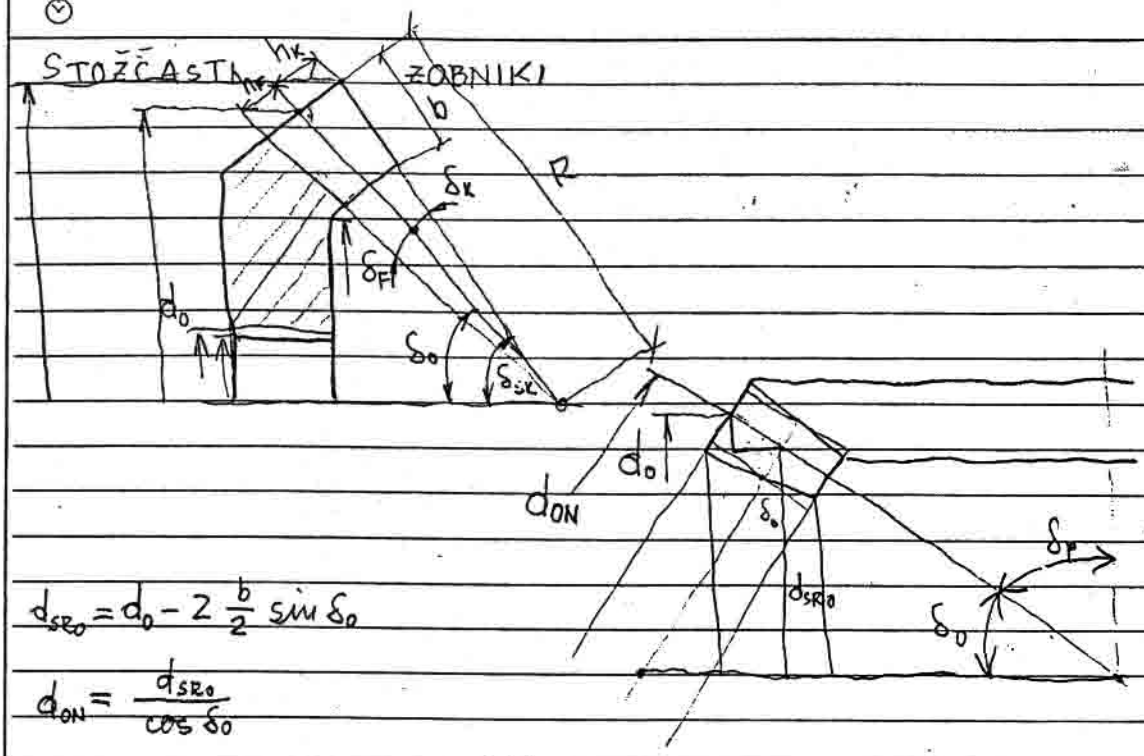
$\varepsilon_{\alpha\beta} < \varepsilon_{\alpha}$ NORM. ZOB.

Pri + korekciji naredimo zobe na istem osn. krogu, pri poševnih zobeh pa se osn. krog dejansko zmanjša



Predmet

STOŽČASTI ZOBNIKI

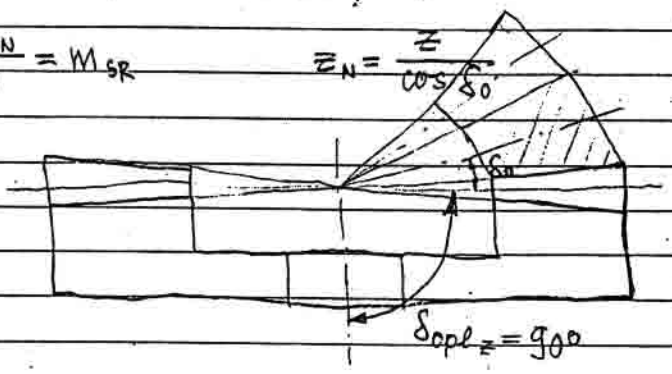


$$d_{sR_0} = d_0 - 2\frac{b}{2}\sin\delta_0$$

$$d_{ON} = \frac{d_{sR_0}}{\cos\delta_0}$$

$m_{SR} \rightarrow d_{sR_0}$ $\quad m_{SR} = \frac{\pi d_{sR_0}}{z}$

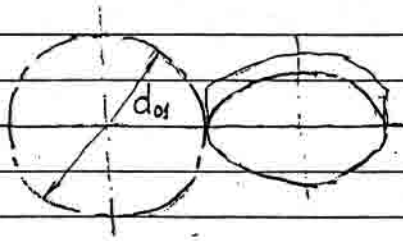
$$\frac{\pi d_{ON}}{z_N} = m_{SR} \qquad z_N = \frac{z}{\cos\delta_0}$$

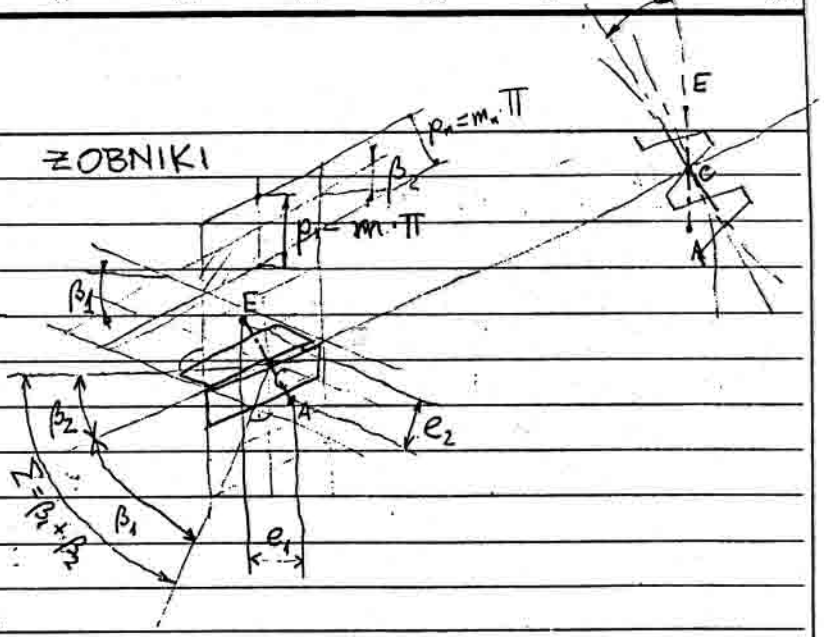


$$i = \frac{z_2}{z_1}$$

Predmet

VIJAČNI ZOBNIKI





$$d_{01} = m \cdot z_1$$
$$d_{02} = m \cdot z_2$$

$$m = \frac{m_n}{\cos\beta}$$

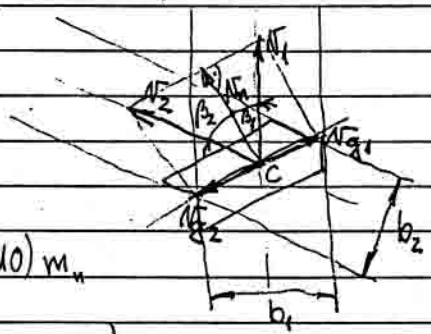
$$\tan\alpha = \frac{\tan\alpha_n}{\cos\beta}$$

$$z_n \cong \frac{z}{\cos^3\beta}$$

$$a = \frac{m_n}{2}\left(\frac{z_1}{\cos\beta_1} + \frac{z_2}{\cos\beta_2}\right)$$

Kinematika in dinamika

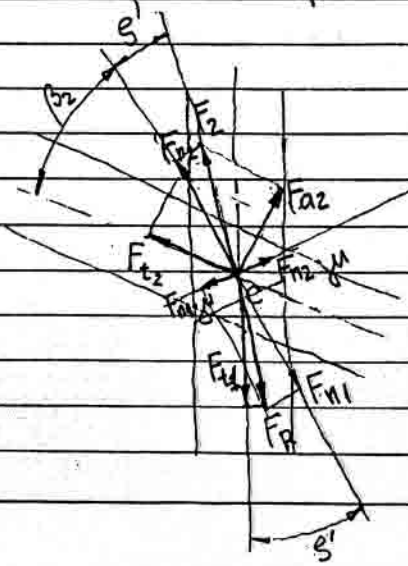
$N_w = N_e$

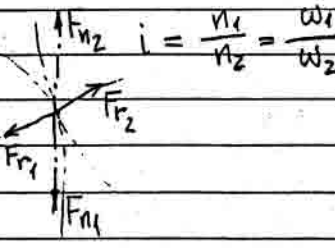


$$b \cong (5 \div 10)\, m_n$$

$$N_{g1} + N_{g2}$$
$$N_g = N_{g1} + N_{g2} = N_1 \sin\beta_1 + N_2 \sin\beta_2$$
$$N_{g1} = N_1 \cdot \sin\beta_1$$
$$N_{g2} = N_2 \cdot \sin\beta_2$$
$$N_g = N_1 \frac{\sin\Sigma}{\cos\beta_2}$$

$$N_1 = \pi\, d_{01} \cdot n$$





$$i = \frac{n_1}{n_2} = \frac{\omega_1}{\omega_2}$$

Predmet

$\tan \varrho' = \frac{\mu}{\cos\beta}$

$F_{t_1} = \frac{T_1}{r_{o1}}$

$F_{a_1} = F_{t_1} \cdot \tan(\beta_1 - \varrho')$

$F_{r_1} = F_{t_1} \frac{\tan\alpha_n \cdot \cos\varrho'}{\cos(\beta_1 - \varrho')}$

$F_{t_2} = F_{t_1} \frac{\cos(\beta_2 + \varrho')}{\cos(\beta_1 - \varrho')}$

$F_{a_2} = F_{t_2} \cdot \tan(\beta_2 + \varrho')$

$\pi_n = N_1 \cdot \cos\beta_1 = N_2 \cdot \cos\beta_2$

Izkoristek:

$\eta = \frac{F_{t_2} \cdot N_2}{F_{t_1} \cdot N_1} = \frac{F_{t_1} \frac{\cos(\beta_2 + \varrho')}{\cos(\beta_1 - \varrho')} \cdot N_2}{F_{t_1} \cdot N_2 \frac{\cos\beta_2}{\cos\beta_1}}$

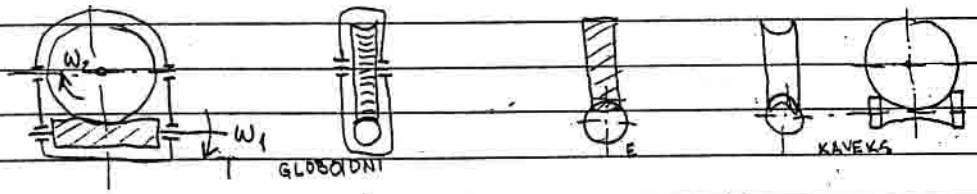
$\eta = \frac{\cos(\beta_2 + \varrho')\cos\beta_1}{\cos(\beta_1 - \varrho')\cos\beta_2}$

$P_1 = T_1 \cdot \omega_1$

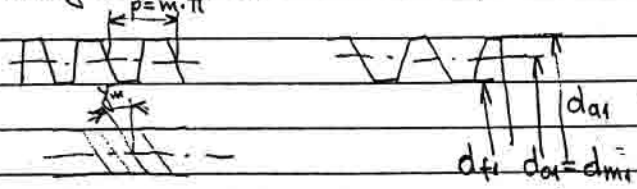
$P_2 = \eta \cdot P_1$

$\Sigma = 90°$: $\eta_{90°} = \frac{\tan(\beta - \varrho')}{\tan\beta}$

POLŽEVA GONILA



geometrijske mere



$p_{a1} = m \cdot \pi$

$d_{m1} = m \cdot q$

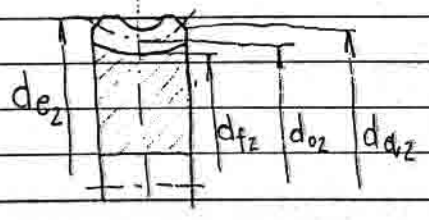
$q = 8 \div 20$

$d_{m1} = 1{,}4\, d_g + 2{,}5m$ polž in gred iz enega kosa

$d_{m1} \geq 1{,}8\, d_g + 2{,}5m$

$d_g \approx 6{,}5 \sqrt[3]{T_1}$

polževo kolo



$d_{o_2} = m \cdot z_2$

$i = \frac{z_2}{z_1}$ $\quad z_1 = 1$

$d_{f_2} = d_{o_2} - 2{,}4m$

$d_{a_2} = d_{o_2} + 2m$

$b_2 = \sqrt{d_{a1}^2 - d_{m1}^2} + 2m$

Predmet

NOT. UBIRNA TOČKA STOŽ. (OBLIKA VIJAČNIKA, DESNA HITR. POLŽ (SILE)

$b_2 \cong 0{,}8\, d_{m1}$

$d_{e2} \cong d_{a2} + m$

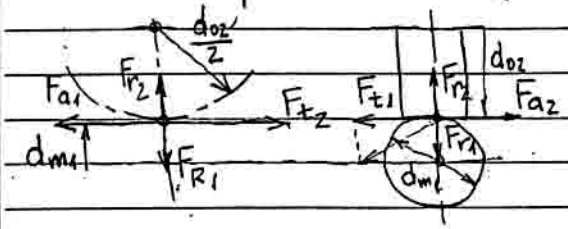
Izkoristek

$\eta_p = \frac{\tan\gamma_m}{\tan(\gamma_m + \varrho')}$

$\eta_c = \eta_p \cdot \eta_l$

z_1	1	2	3	4
η_c	0,7	0,8	0,85	0,9

Sile na polžnem gonilu



$F_{t1} = \frac{2T_1}{d_{m1}} = F_{a2}$

$F_{r1} = F_{t1} \frac{\tan\alpha_n \cdot \cos\delta'}{\sin(\gamma_m + \varrho')}$

$F_{a1} = \frac{2T_2}{d_{o2}} = F_{t2}$

Trdnostni preračun

① Korenska trdnost

$C = \frac{F_{t2}}{z \cdot b_2 \cdot p_a} \leq C_{dop}$

$F_{t2} = F_{a1} = \frac{F_{t1}}{\tan(\gamma_m + \varrho')}$

$b_2 = \sqrt{d_{a1}^2 - d_{m1}^2}$

z_2	17	20	25	30	35	40	50	60
Z_v	0,6	0,68	0,8	0,95	1,07	1,16	1,31	1,43

C_{dop} N/mm²

Material polža	Material pol. kolesa	mazanje s potapl. 1	4	8	ročno mazanje 1	4	8
16MnCr5 ali C15 HB=600	Gz-SnBz12	8	4,5	2,5	8	9,5	12,5
	G-SnBz12	6,5	3,5	2	6,5	7,5	10
	G.K-AlSi10Mg G.K-AlCu4Mg	6,5	4	2	6,5	8,5	11
kaljen	GB-ZnAl4Cu1	3,5	2,5	1,5	4	5	7
brušen	GG-20; GG-25	4	2	—	—	—	—
C45 poboljšan brušen	Gz-SnBz12	4	3,5	1,5	1,5	5,5	8
	G-SnBz12	3,5	3	1,2	1,2	4,5	6,5
C45 ali St70 poboljšan, brušen	GG-20; GG-25	3	1,4	—	—	—	—

$\sigma_{H\,dop}$ [N/mm²]

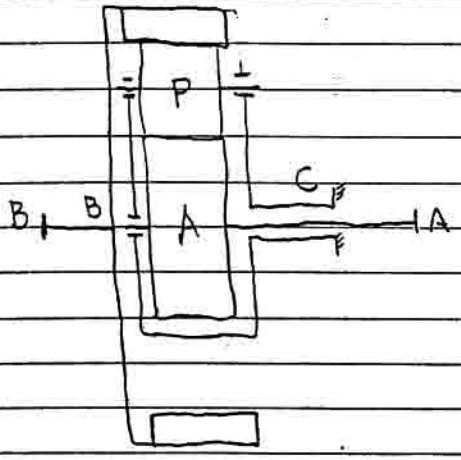
v_g [m/s] →	8	11	13	15
	500	520	540	550
	280	290	350	320
	220	245	275	295

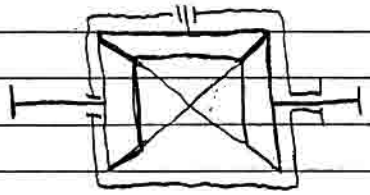
② Hertzov tlak

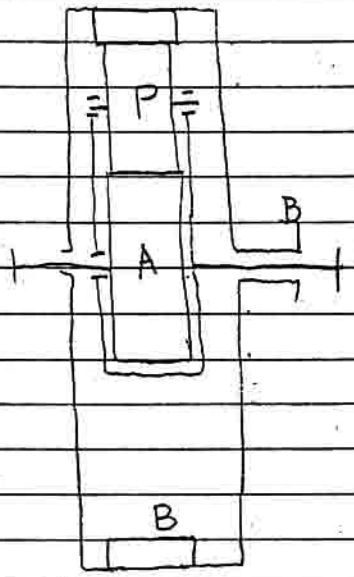
$\sigma_H = \sqrt{\frac{F_{t2}}{b_2 \cdot d_{o2}}} \cdot Z_H \cdot Z_M \cdot Z_\varepsilon \leq \sigma_{H\,dop}$

Predmet

PLANETNA GONILA







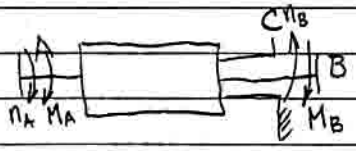
M_A, M_B, M_C
M_A ...
P_A ...
i (ena gred miruje)
k (mirijo se vse tri gredi)
M_A, M_B, M_C če se vse mirijo

$i_{A/B} = \frac{M_A}{M_B}$ C MIRUJE
$k_{A/B} = \frac{M_A}{M_B}$ $C \neq 0$
$i_{B/C} = \frac{1}{i_{C/B}}$

$M_A + M_B + M_C = 0$
$P_A = M_A \cdot \omega_A = M_A \cdot 2\pi n_A$
$\frac{P_A}{2\pi} = M_A n_A$
RAZMERNIK
$\varepsilon_{A/B} = \frac{P_A}{P_B}$ (negativen)

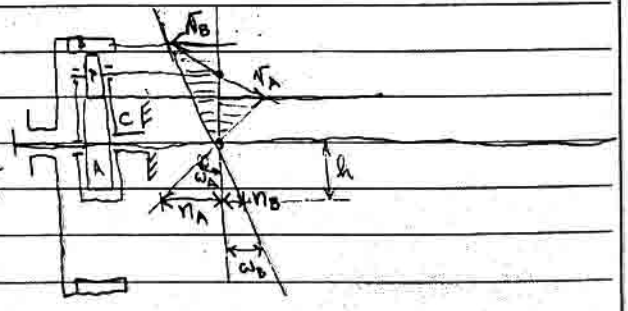
$P_{dv} \equiv P_A = >0$ ⊕
$P_{od} \equiv P_B = <0$ ⊖

$\varepsilon_{A/B} = -\frac{M_A n_A}{M_B n_B} = -\frac{M_A}{M_B} \cdot i_{A/B}$



$M_C = 0$

STAZIUM PRESTAVA $\begin{cases} i_{A/B} = \frac{M_A}{M_B} \\ n_C = 0 \end{cases}$



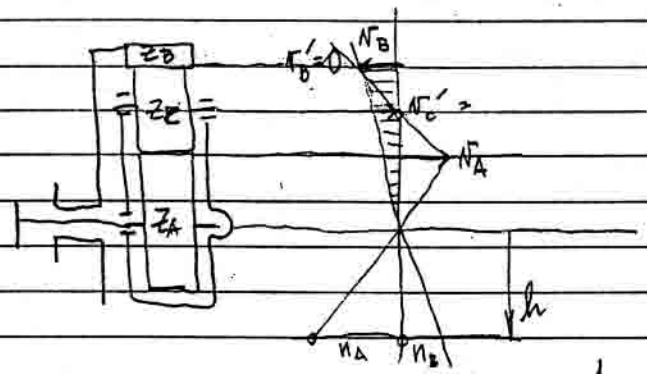
Predmet

$$i_{A/B} = \left| \frac{n_A}{n_B} \right|$$

$$i_{A/B} = \frac{n_A}{-n_B} = -\frac{n_A}{n_B} = -\frac{r_B}{r_A}$$

$$n_A : h = 2\pi n_A : r_A$$
$$n_B : h = 2\pi n_B : r_B$$

$$i_{A/B} = -\frac{n_A}{n_B} = -\frac{z_B}{z_A}$$



$$n_A' = n_A - n_B$$
$$n_C' = -n_B$$

$$i_{A/C} = \frac{n_A'}{n_C'} = \frac{n_A - n_B}{-n_B} = 1 - \frac{n_A}{n_B}$$

$$i_{A/C} = 1 - i_{A/B}$$

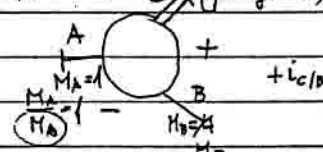
$$i_{A/B} \cdot i_{B/C} \cdot i_{C/A} = i_{AB}\left(1 - \frac{1}{i_{A/B}}\right)\left(\frac{1}{1 - i_{A/B}}\right)$$

$$r_B = r_A + d_C$$

$$\frac{m \cdot z_B}{2} = \frac{m \cdot z_A}{2} + m z_C$$

$$z_C = \frac{z_B - z_A}{2}$$

$+i_{A/C} = 5$ + C (5) → sumarna gred (pl. gred)



$i_{A/C} = 1 - i_{A/B}$
1+4

$$\varepsilon_{A/B} = -\frac{M_A}{M_B} \cdot i_{A/B}$$

$$\frac{M_B}{M_A} = 4$$

$$i_{A/B} = \frac{M_B}{M_A} = \frac{-4}{1}$$

$$1 \Rightarrow \eta = 1$$

Če ena gred miruje so prestave notranji prestave;
če se vse tri vrtijo so pa zunanje prestave

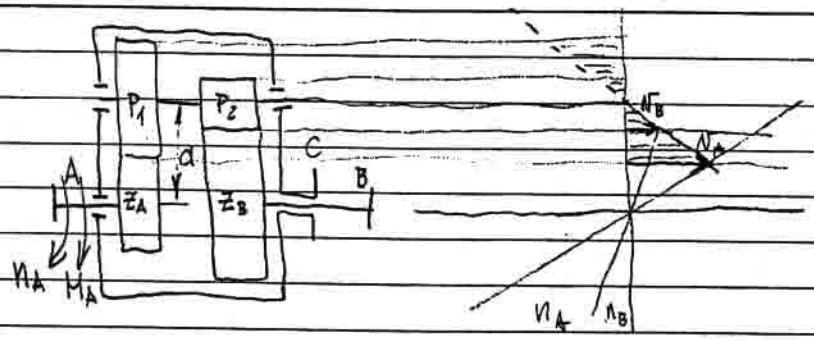
$$K_{A/C} = m_A / m_C$$

$$i_{B/C} = \frac{n_B}{n_C} = \frac{m_B - m_A}{m_C - m_A} = (1 - K_{B/A})/(1 - K_{C/A})$$

$$i_{A/C} = \frac{(1 - K_{A/B})}{1 - K_{C/B}}$$

$$K_{A/B} \cdot K_{B/C} \cdot K_{C/A} = 1$$

Predmet



$$i_{A/B} = \frac{n_A}{n_B}$$

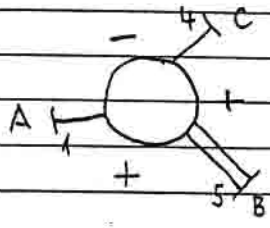
$$i_{A/B} = +$$

$$\frac{n_B}{n} = \frac{z_B \cdot m_B \cdot \omega_B}{z_B \cdot m_B}$$

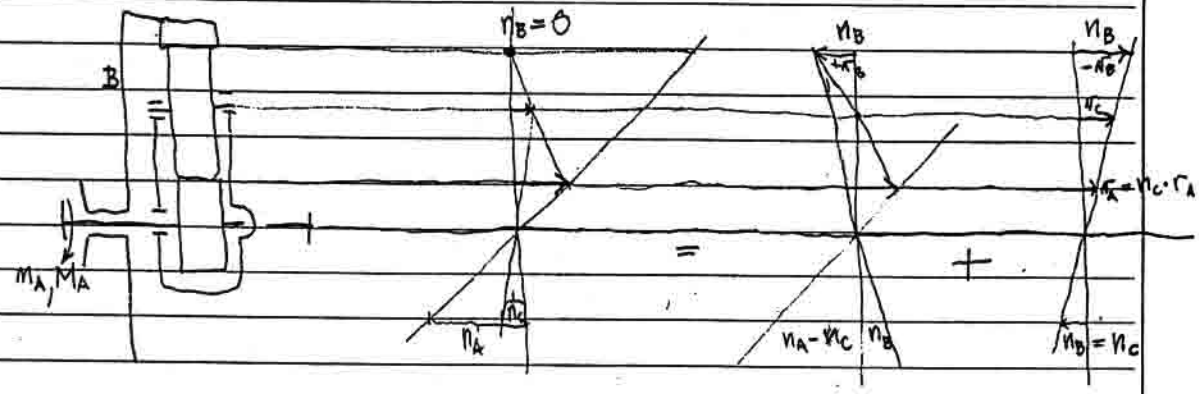
$$\frac{n_B}{n_A} = \frac{m_B \cdot z_{P2}}{m_A \cdot z_{P1}}$$

$$\frac{n_A}{n} = \frac{z_A \cdot m_A \cdot \omega_A}{z_A \cdot m_A}$$

$$i = + \frac{z_B}{z_A} \cdot \frac{z_{P1}}{z_{P2}}$$



$$i_{A/C} = \frac{n_A}{n_C} = 1 - i_{A/B}$$
$$= 1 - 5 = -4$$



$P_{KO} = 2\pi M_A (n_A - n_C)$ - kotalna moč

$P_{SK} = 2\pi M_A (n_C)$

GONILA = DELITVIJO MOČI

$P_{dr} = P_{KO} + P_{SK} = 2\pi M_A n_A$

$$\varepsilon_{KO/A} = \frac{P_{KO}}{P_A} = \frac{n_A - n_C}{n_A} = 1 - i_{C/A} = i_{C/B}$$

$$\varepsilon_{SK/A} = \frac{P_{SK}}{P_A} = \frac{n_C}{n_A} = i_{C/A}$$

$$\varepsilon_{KO/A} + \varepsilon_{SK/A} = i_{C/B} + i_{C/A} = 1$$

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

I II III IV V VI VII VIII IX X XI XII

Predmet .