STROJNI ELEMENTI I

2000 / 2001

I

IZDELOVALNO oz. PROIZVODNO STROJNIŠTVO $\xrightarrow{\text{IND.}}$ KONSTRUKTERSVO IN RAZVOJ

II

IZDELOVALNI PROGRAM

ENERGETSKO STROJNIŠTVO → ENERGETSKO STROJNIŠTVO

III

PROCESNO STROJNIŠTVO → PROCESNO STROJNIŠTVO

IV

MEHATRONSKI SISTEM

senzorji regulacije aktuatorji

PROIZVODNO STROJNIŠTVO → UPORABA

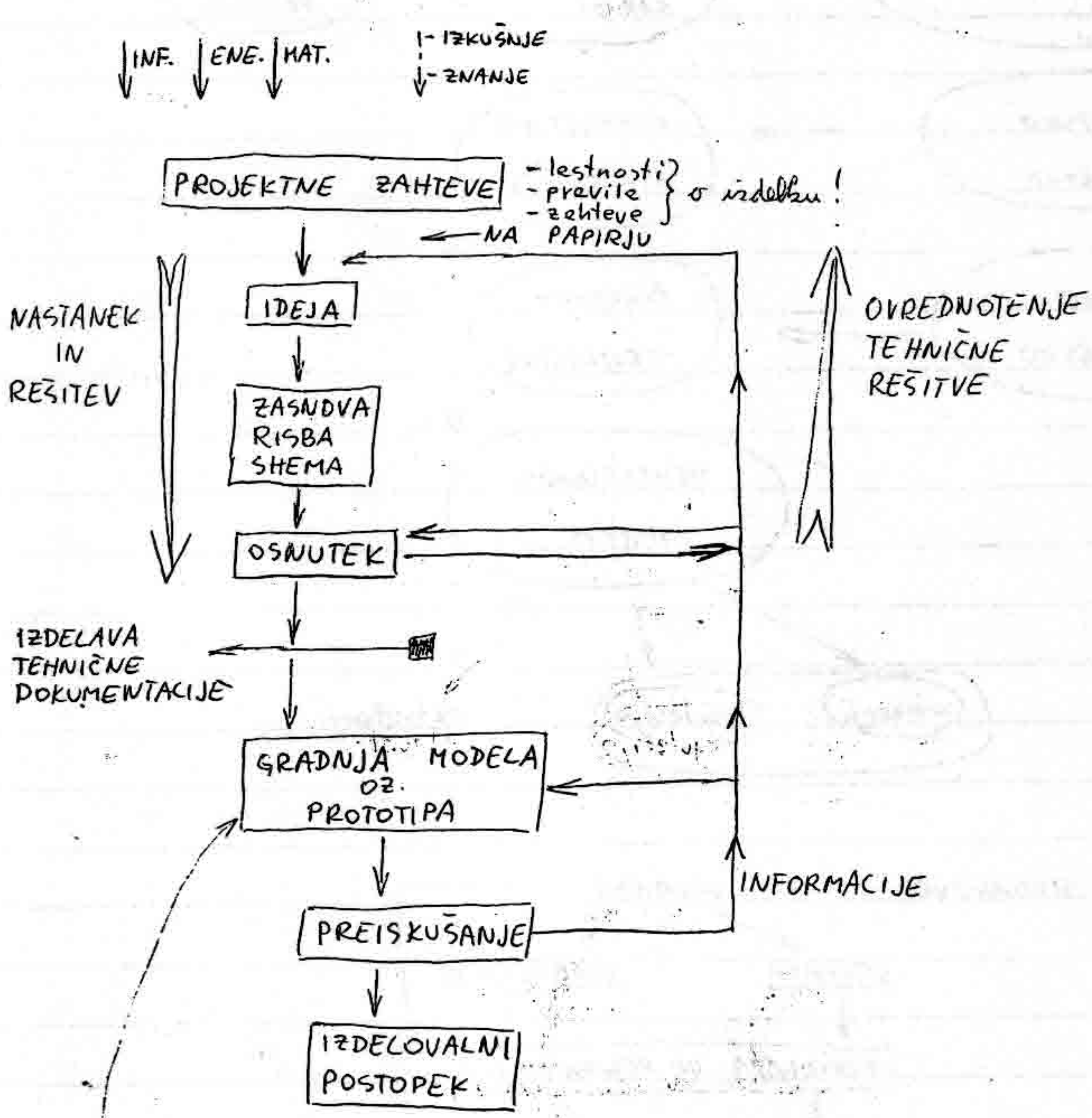
UPORABA VZDRŽEVANJE

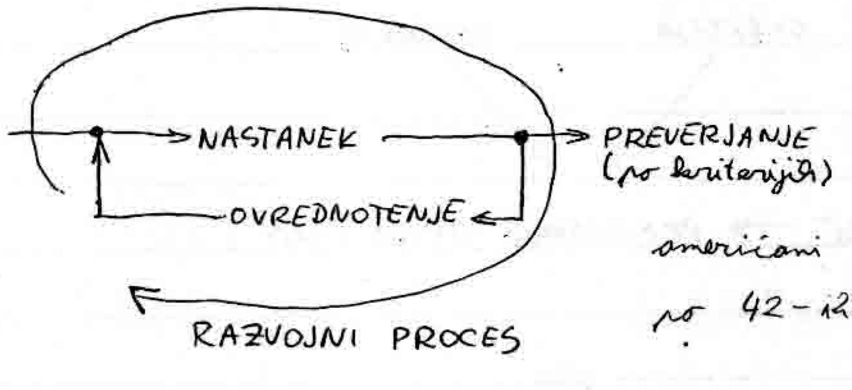
RECIKLAŽA IN REGENERACIJA

ENERGIJA MATERIAL

INFORMACIJE → PROIZVODNO STROJNIŠTVO

Proizvodno strojništvo



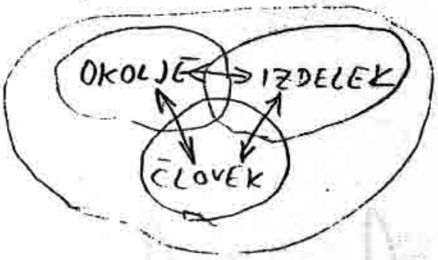


americani morajo izdelati poročilo po 42-ih kriterijih

ATRAPA - (avto je na zunaj točno tak kot bi naj bil, znotraj pa ga ni

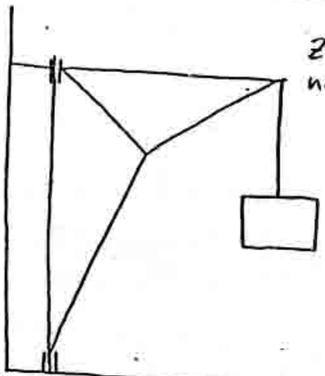
KRITERIJ ZA VREDNOTENJE KONSTRUKCIJE:

1. funkcionalnost
2. dimenzijska primernost
3. ekonomska vrednost
4. ekološka -//-
5. estetska -//-
6. regenerabilnost
7. vzdrževalnost
8. energetska primernost
9. primernost uporabljenih materialov



mehatronika
- senzorika
- regulacijski
- aktuatorski: mehanski, električni

PREVERJANJE DIMENZIJSKE PRIMERNOSTI:

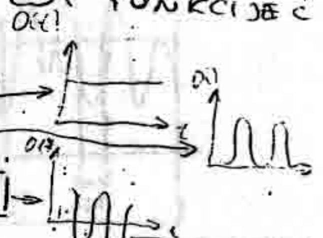


Zunanje obremenitve
notranje -//-
1) poznana oblika
2) obremenitveno stanje:
- meh. obr.
- toplotne -//-
- kemične -//-
- sevanja (atomske)

Napetost je notranja obremenitev na enoto prereza.

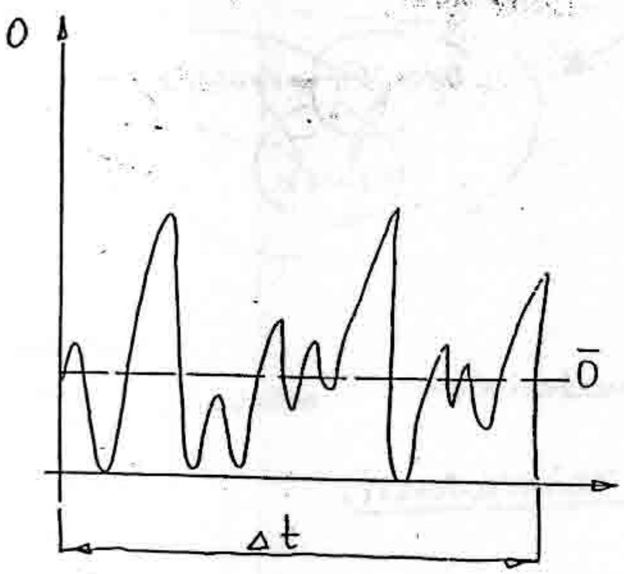
MEHANSKE OBREMENITVE: OBREMENITVE KOT FUNKCIJE Č

OBREMENITEV (O(t))
- DETERMINISTIČNE
  - STATIČNE
  - UTRIPNE
  - IZMENIČNE
- NAKLJUČNE
  - STACIONARNE
    - ERGODIČNE
    - NEERGODIČNE
  - NESTACIONARNE



Deterministične obremenitve: Za vsak trenutek časa lahko s 100% gotovostjo povemo kakšna je obremenitev.
Verjetnost, da je temu tako je 1. $\boxed{R=1}$
Naključne obremenitve: So tiste pri katerih napovemo kakšna bo obremenitev v določenem trenutku, ob pogoju da bo v tem trenutku obremenitev $O_t(P)$
V določenem trenutku sile ne moremo natančno določiti, zato je verjetnost manjša od 1 $\boxed{R < 1{,}0}$

1

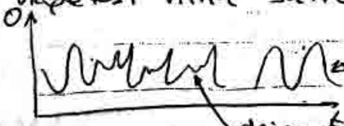


$$\overline{O} = \frac{1}{m}\cdot\sum_{i=1}^{m} O_i$$

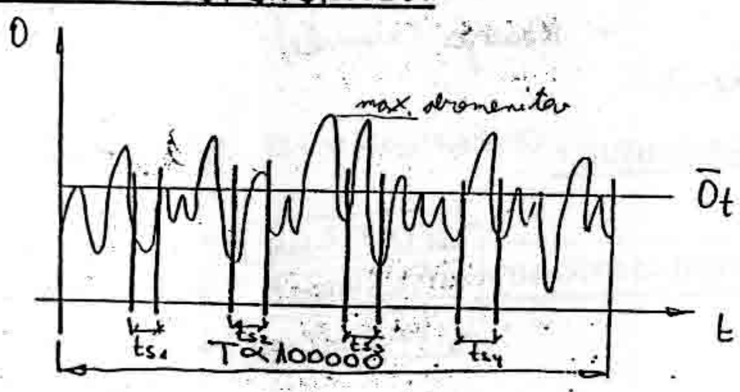
STACIONARNA OBREMENITEV

Statistični parametri v nekem obdobju so konstantni. Stacionarna obremenitev ima dve podskupini: ergodična in neergodična obr.

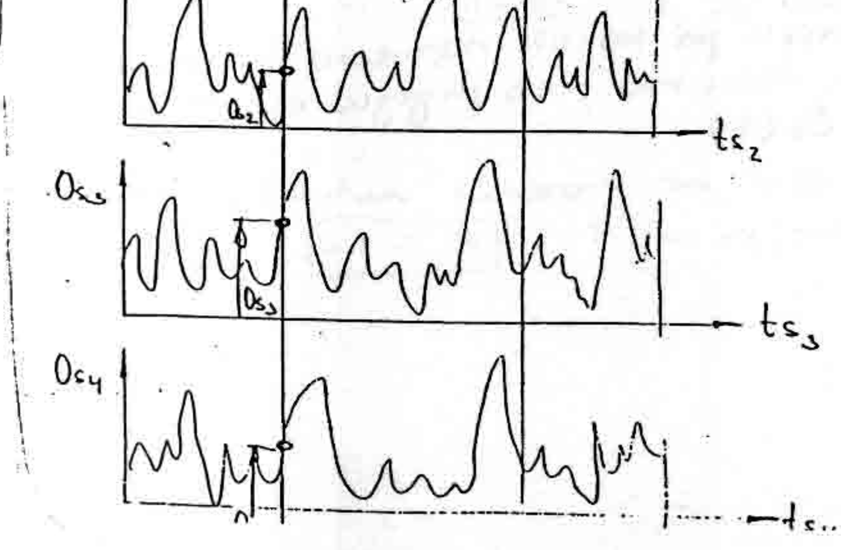
Poenostavimo obremenitev (npr. kot v šoli napetost niha samo med min in max)



ERGODIČNA OBREMENITEV:



izberemo štiri vzorce pri različnih razmerah.



$$\overline{O_T} = \frac{1}{k}\cdot\sum_{i=1}^{k} O_{si}$$

k - število vzorcev

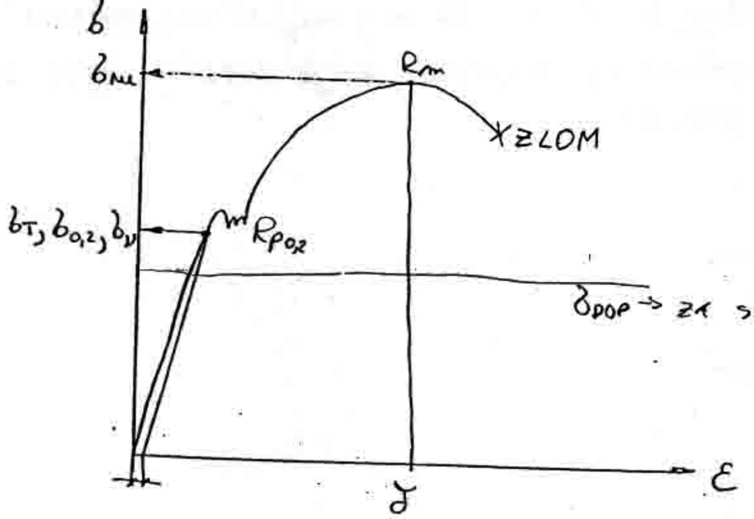
Če je povprečenje po času ≈ povprečenju po ansemblu (po vzorcih) potem pravimo da je proces ERGODIČEN

glede na:
- velikost obremenitve
- velikost prereza
- mesta koncentracije napetosti
- vrste materiala

Preračun < sklutimo / iskušnje / vrsta materiala

KRITERIJ O VRSTI POŠKODBE:

Poškodbe:
- trenutni lom
- utrujenostni lom
- obraba
- deformacije



σ_m - natezna porušna trdnost

$\sigma_T \sim \sigma_{0,2} \sim \sigma_T \sim \sigma_y$ - meja plastič

$\sigma_{DOP} = \frac{R_{p0,2}}{S}$ ali $\sigma_{DOP} = \frac{R_m}{S}$

Napetost je merilo obremenitve v kritičnem prerezu

$$\sigma = \left\{ \frac{O}{A_{KRIT}} \right\}$$

Kriterij za poškodbo:

- statične obremenitve

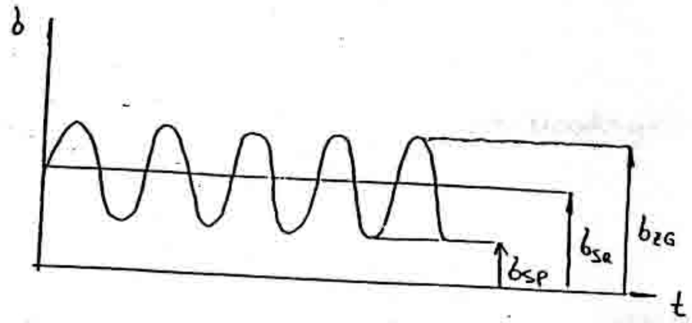
σm - dejanski prelom

$\sigma_{0,2}$ - prevelika deformacija

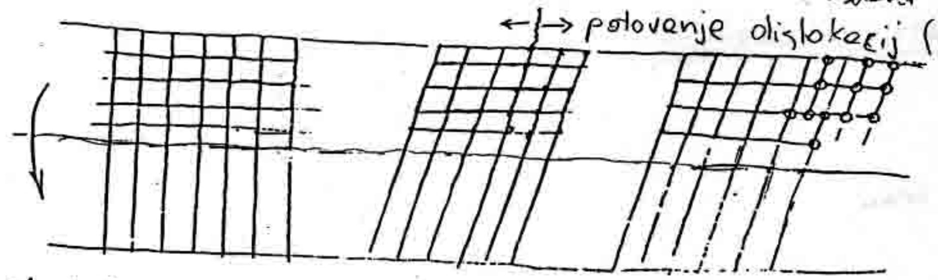
Kritična poškodba:

- pravo porušitev (σ_m, δ)
- $0{,}2\ \%\ \varepsilon_{pl}$ $(\sigma_{0,2})$

DISLOKACIJE

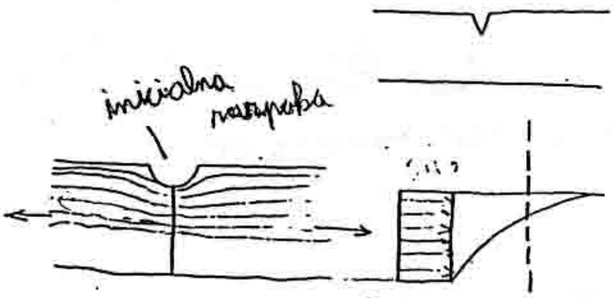


Dislokacije so nezdružljivost elementov v kristalni rešetki.



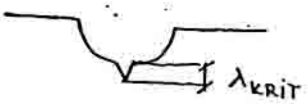
zdis kristalov, prevelika strižna napetost

Nastajanje dislokacij, ki potujejo v coneh največjih napetosti. Ko jih je zadosti, nastane inicialna razpoka, ki je mesto, kjer se zapazi oster prehod na površini.



Iz inicialne poškodbe pridemo do tehnične poškodbe

Zaradi inicialne razpoke pride do dinamičnega loma



λ – velikost razpoke

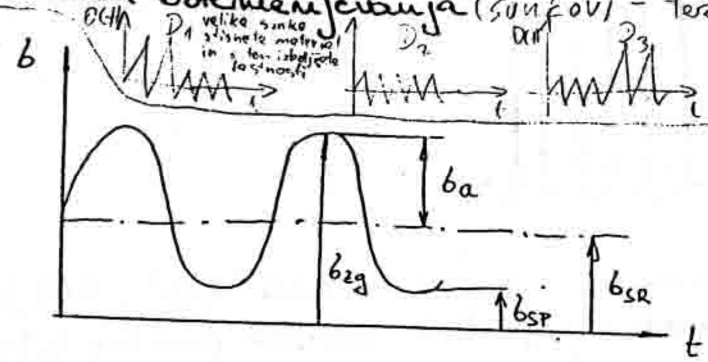
N – število spremenljive obremenitve

Najbolj nevarna je 2., ker se počasi kopičijo razpoke, potem pa hitro narastejo na λ_{KRIT}.

VPLIVI NA UZDRŽLJIVOST (UTRUJANJE)

- amplituda σ_a (sunkov)
- število nihajev N (sunkov)
- srednja vrednost napetosti σ_{sr} (sunkov)
- gradient spremembe (sunkov)
- vrstni red obremenjevanja (sunkov) - težko jo je dokazat in prikazat

TO LAHKO IZLOČIMO S ŠTEVNIMI METODAMI IZ ČASOVNE ZGODOVINE



$D_1 < D_2 < D_3$ (poškodbe) poškodba

$\sigma_{zg} = \sigma_{max}$

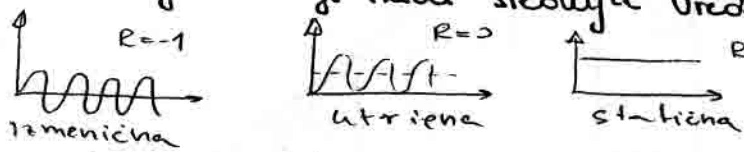
$\sigma_{sp} = \sigma_{min}$

$\sigma_{max} = \sigma_{sR} + \sigma_a$

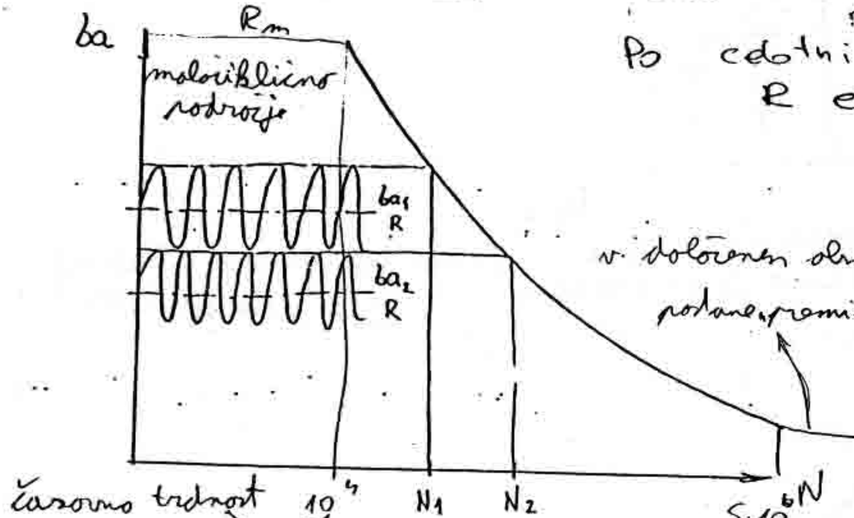
$\sigma_{min} = \sigma_{sR} - \sigma_a$

R - faktor dinamičnosti obremenitve
$$R = \frac{\sigma_{max}}{\sigma_{min}} = \frac{\sigma_{zg}}{\sigma_{sp}} = \frac{\sigma_{sR}+\sigma_a}{\sigma_{sR}-\sigma_a}$$

R = isti $\Rightarrow$ če je amplituda zmanjšana je tudi srednja vrednost zmanjšana



WÖHLERJEVA KRIVULJA:



Po celotni wohlerjevi krivulji je R enak.

v določenem območju $\frac{\sigma_{a_1}}{\sigma_{a_2}} = \left(\frac{N_2}{N_1}\right)^{\varkappa}$ $\quad \left(\frac{\sigma_{zg1}}{\sigma_{zg2}}\right)^{\varkappa} = \frac{N_2}{N_1}$

postane premica

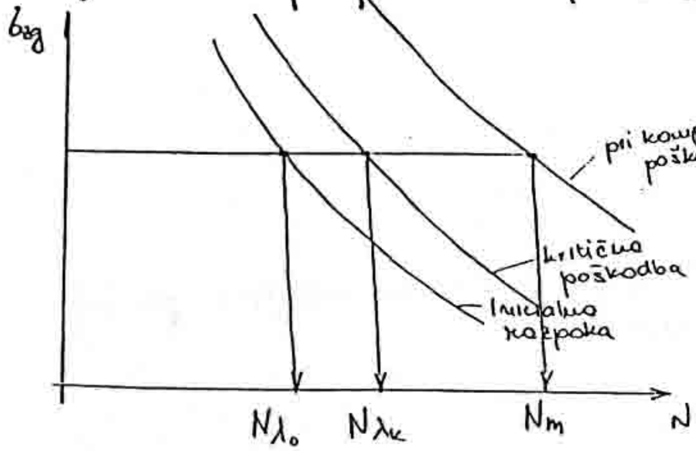
$\varkappa = 4 \div 7$ - utrujenostna poškodba

$\varkappa = 3$ - poškodba zaradi obrabe

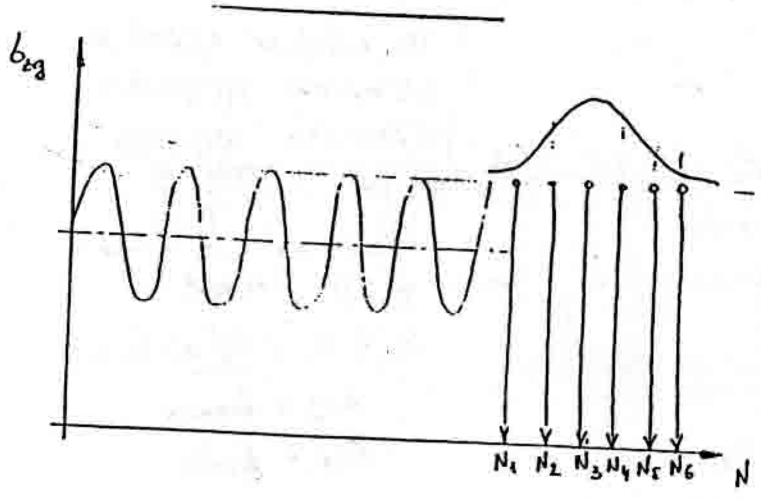
$\varkappa = 3{,}5$ - Hertzov tlak

trajna dinamična trdnost

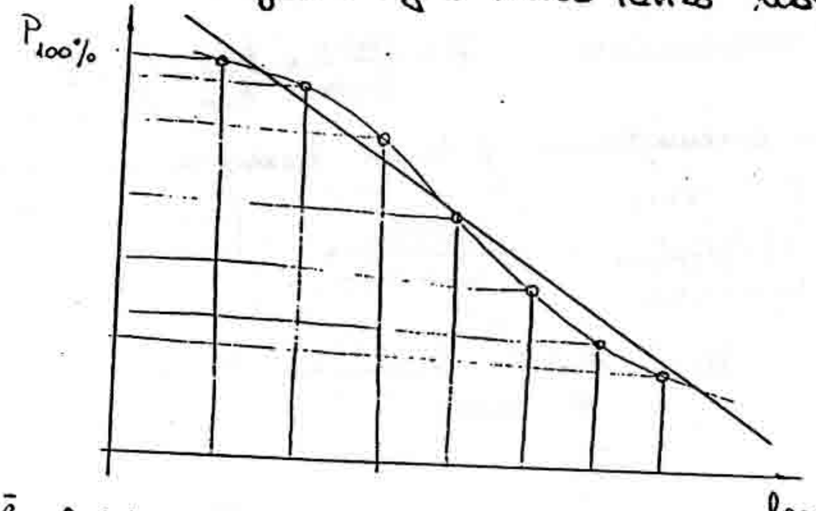
Wöhlerjevo krivuljo ponavadi podano za σ_{zg}



- Pri zelo velikih napetostih doseže neč maksimum kjer ne more več višje [Rm]
- Pri zelo majhni napetosti se preizkušanec sploh prelomi več. To pomeni da pri majhni napetosti krivulja postane premica

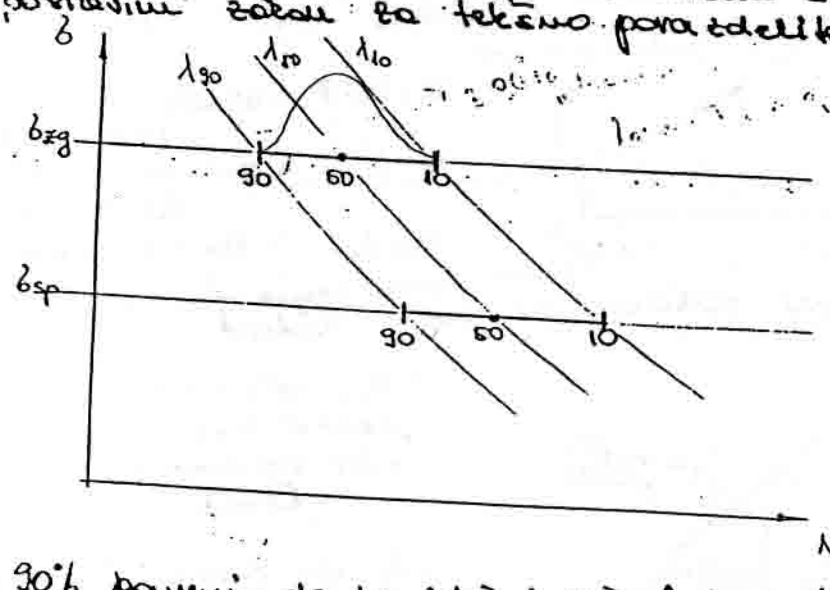


Rangiramo vrednosti; tem vrednostim priredimo "MOD". MOD je verjetnost, da se bo takšen rezultat pojavil v celotni porazdelitvi s takšno verjetnostjo. Potem lahko narišem zakon verjetnosti



P – verjetnost

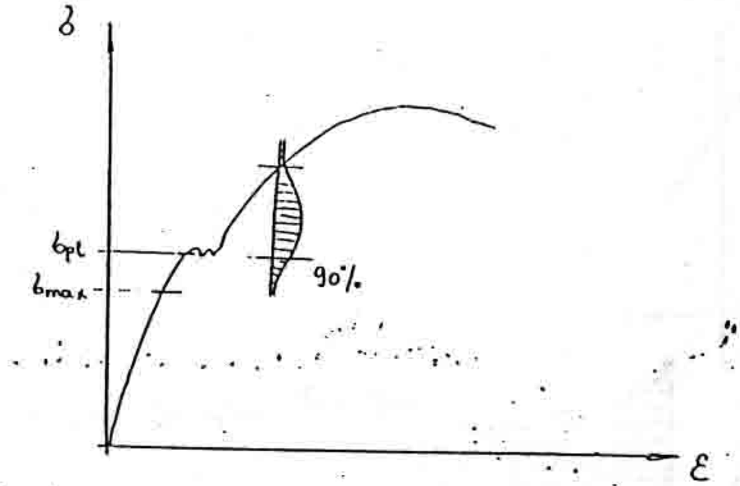
Če lahko porazdelitev aproksimiram s premico potem lahko postavim zakon za takšno porazdelitev. [illegible] N_{90} pri vrg. !



90% pomeni, da bo zdržal več kot je število nihajev pri tej vrednosti. (verjetnost preživetja

DIMENZIONIRANJE : VDI 2226

Statična obremenitev:

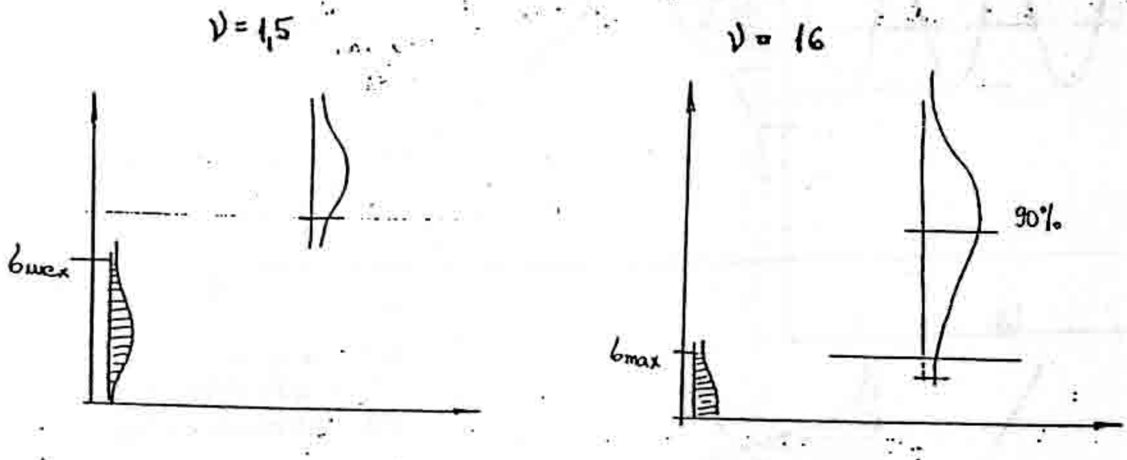


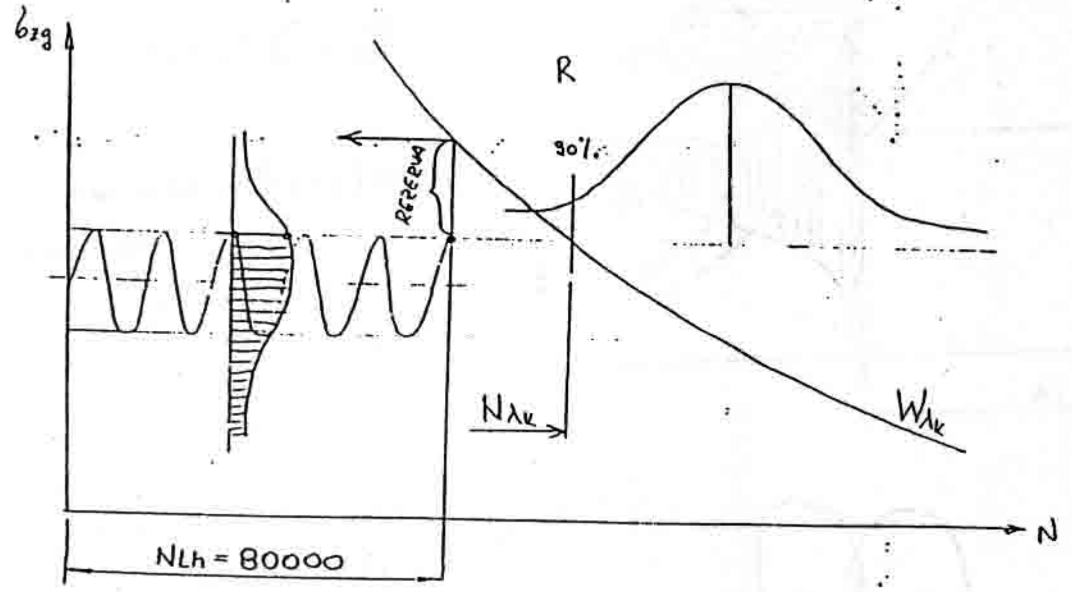
$$\frac{\sigma_{pl}}{\sigma_{max}} = S$$

S - varnost

Ugotoviti moramo mesto največje obremenitve med eksploatacijo

Nosilnost > varnosti

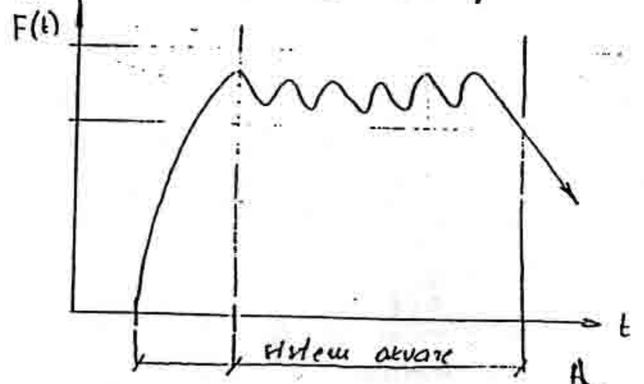


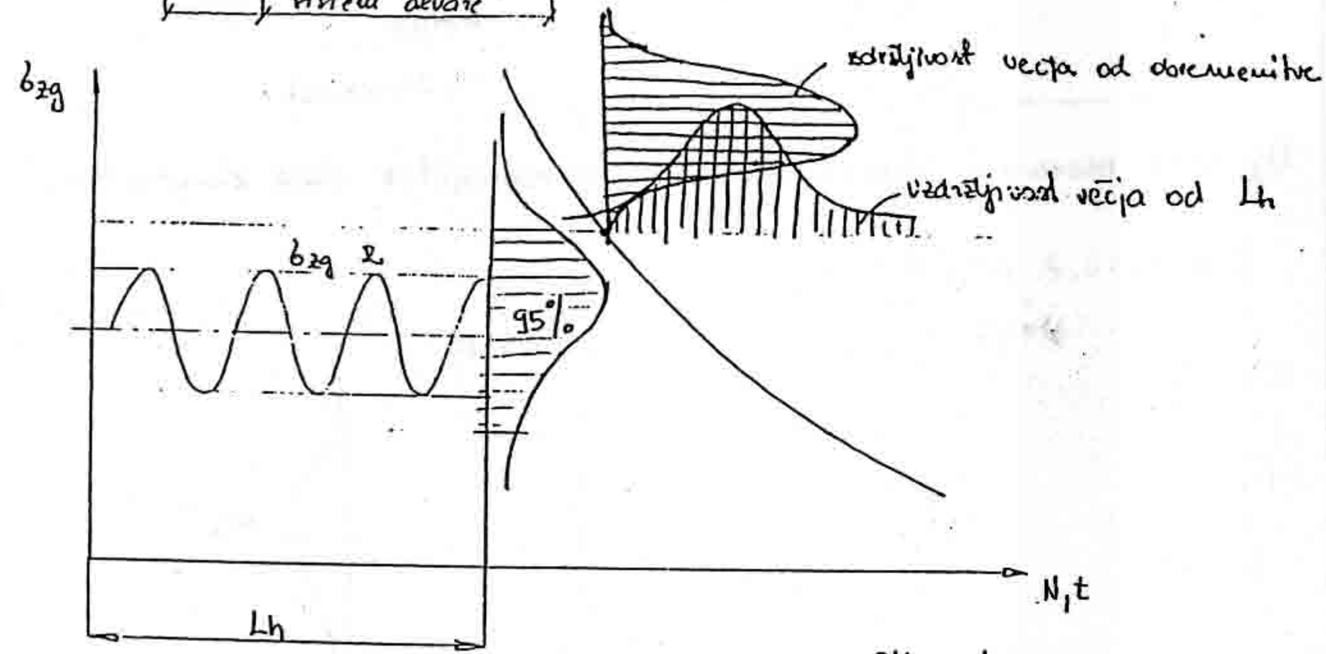


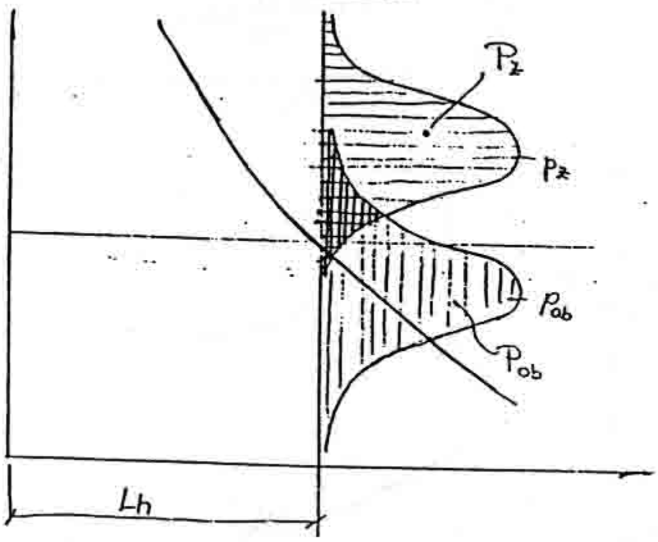
Vzdržljivost > obratovalna doba

Ker smo za celo življ. dobo predvidel max. obremenitev. Tak način dimenzioniranja, je predimenzioniranje

nesljivost je verjetnost da bo proizvod, ko bo začel delovati v danih
ejah funkcionalnosti, obratoval določeno dobo brez okvar



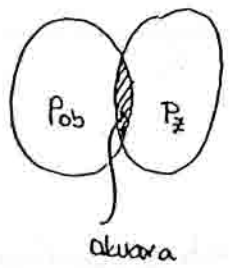




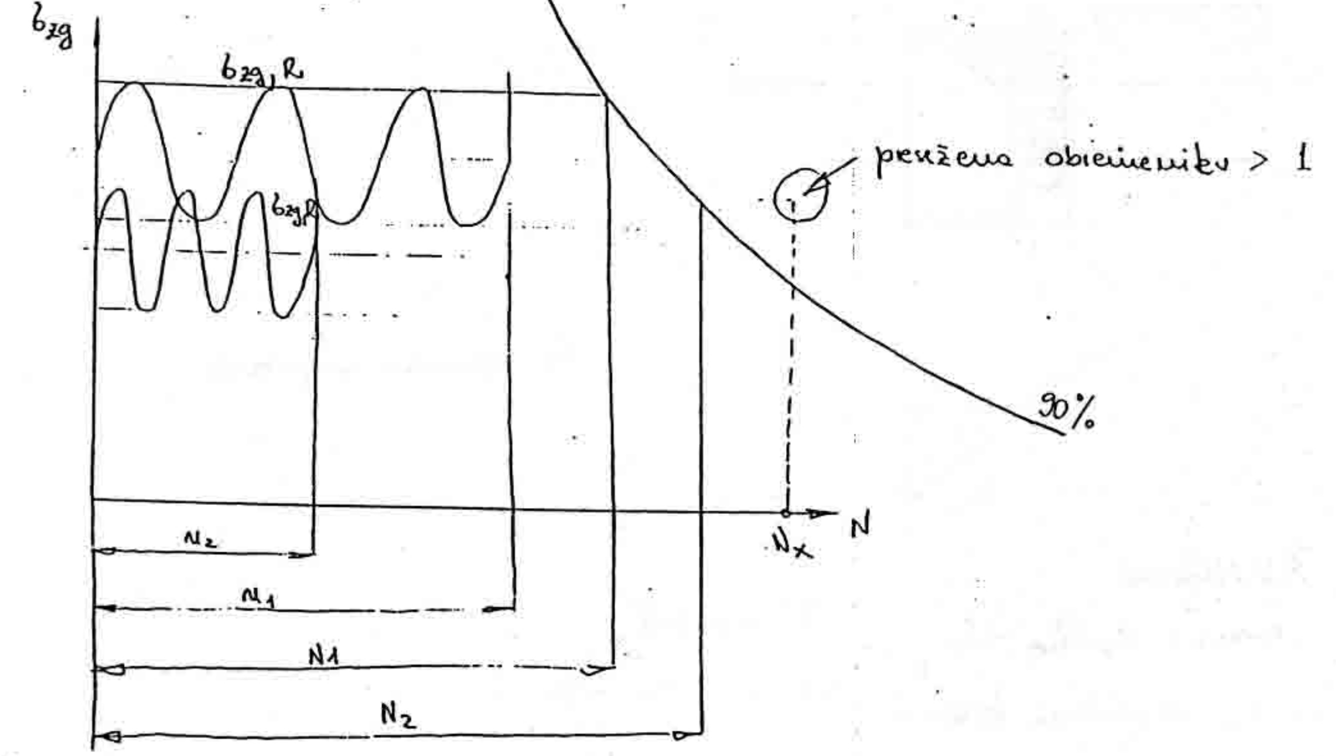
OK - okvara
z - zdržljivost
OB - obremenitev

$$P_{OK} = P_Z \cap P_{OB}$$

zdržljivost < obremenitve ⇒
⇒ okvara



Ta isti del je še obremenjen z eno obremenitvijo pri istem R. Na prvem smo razbral poškodbo N_1 na drugem pa poškodbo N_2, ki se akumulira (seštevá)



Če bi obremenitev trajala do N_x bi se pojavila porušitev

$p_1 \propto \left(\frac{n_1}{N_1}\right) \rightarrow$ linearno akumulacijo poškodbe

$p_2 \propto \left(\frac{n_2}{N_2}\right)$

$\vdots \qquad \vdots$

$p_i \propto \left(\frac{n_i}{N_i}\right)$

PALMGREEN – MINER-jevo PRAVILO: (linearna akumulacija poškodbe)

$$\boxed{\sum_{i=1}^{k} \left(\frac{n_i}{N_i}\right) = a}$$

$0 \leq a \leq 1$

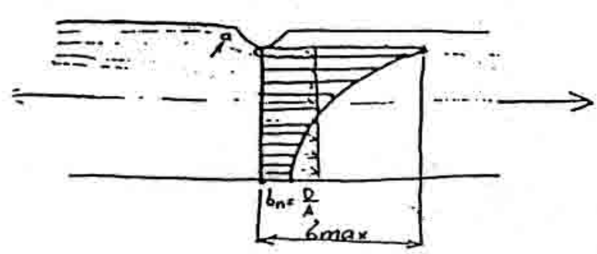
$a = 1 \Rightarrow$ kritična poškodba

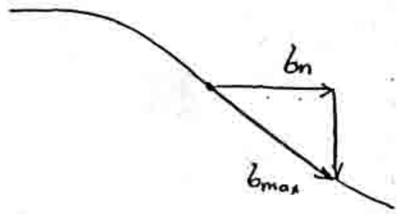
CORTEN – DOLAN-ovo PRAVILO

$$\boxed{\sum_{i=1}^{k} \left(\frac{n_i}{N_i}\right)^{\mu(i)} = \mu(\sigma)}$$

μ - odvisen od redosleda obremenjevanja

i.) ZAREZNI UČINEK:





σ_n - nazivna napetost

Teoretično:

$\sigma_{max} = \alpha_k \cdot \sigma_n \le \sigma_y$ — definicija ne velja

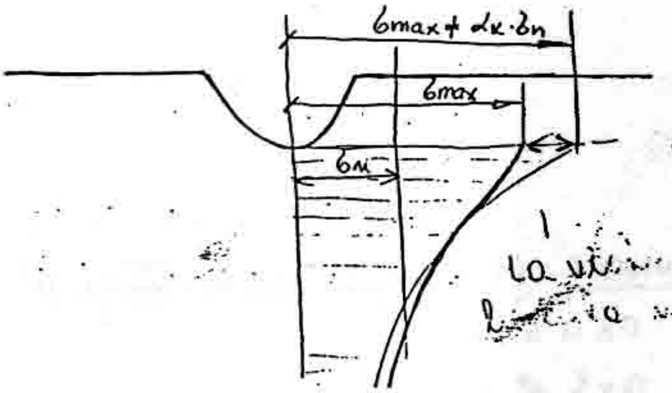
$1 \le \alpha_k \le 8$

α_k - oblikovni faktor

Realno:

$\sigma_{max} = \beta_k \cdot \sigma_n$

β_k - realni faktor $< \alpha_k$



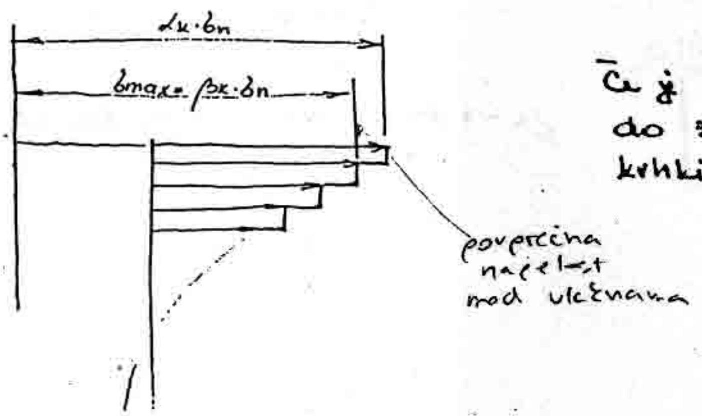
Tista vlakna, ki so močno v meji plastičnosti se bodo razbremenila in se bo σ_{max} zmanjšal zato je $\beta_k < \alpha_k$

[illegible]

$$\beta_k = 1 + \eta (\alpha_k - 1)$$

η – gradient

Če je skok prevelik, bo prišlo do zdrsa in nastali bodo krhki lomi

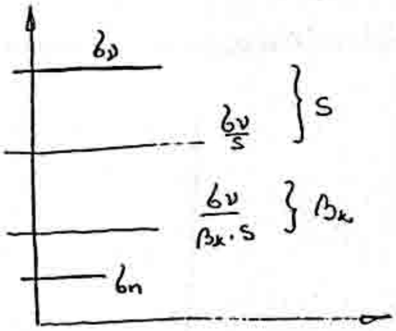


$\beta_k \cdot \sigma_n \leq \sigma_v$

$\beta_k \cdot \sigma_n = \dfrac{\sigma_v}{S}$

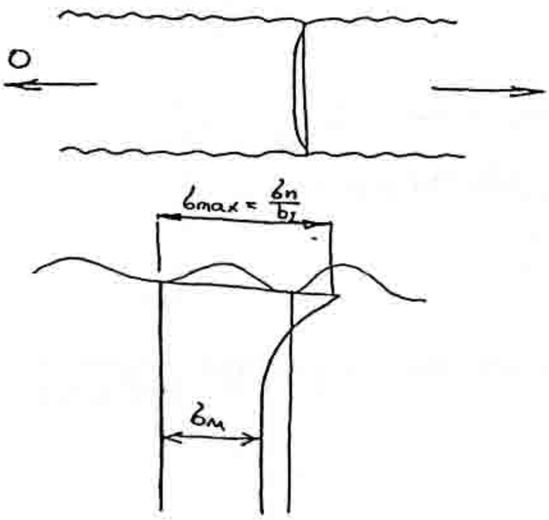
$$\boxed{\sigma_n = \frac{\sigma_v}{\beta_k \cdot S}}$$

$\eta = f\left(\frac{d}{D}, \rho\right)$



β_k - koeficient zareznega, pove kolikokrat je napetost večja ob zarezi, kot bi bilo če ne bi bilo zareze.

2) HRAPAVOST POVRŠINE:



R_t - hrapavost

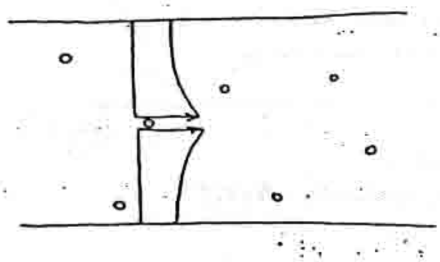
$\sigma_n \cdot \beta_k < \sigma_v \cdot b_2$

$0 < b_2 < 1$

$$\boxed{\sigma_n \leq \frac{\sigma_v \cdot b_2}{\beta_k \cdot S}}$$

3.) VELIKOST PREREZA:

Materiali so nehomogeni (lunkerji, zareze, vključki)



Ob vsaki "lunkerji" nastane konica napetosti, zaradi katerih nastane zareza. Pri večjem prerezu je večja verjetnost, da se bo popušilo vlakno, ki bo močneje obremenjeno ⇒ nepravilno v materialu.

$$\boxed{\sigma_n \leq \frac{\sigma_v \cdot b_1 \cdot b_2}{\beta_k \cdot S}}$$

$0 \leq b_1 \leq 1$

faktor verjetnosti napake

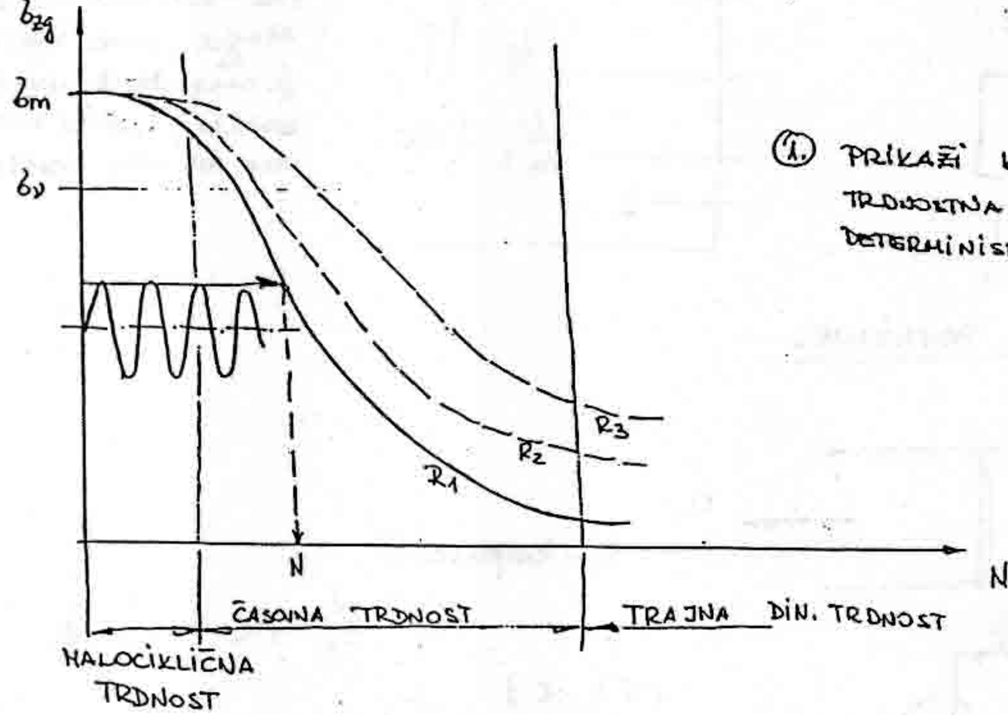
b_1 - faktor b_1 gledamo glede na standardni preizkušanec s prerezom Π, $\overset{5}{\nabla}$ in brez zarez

$b_1 = 1$, če je kontroliran prerez enak prerezu preizkušanca

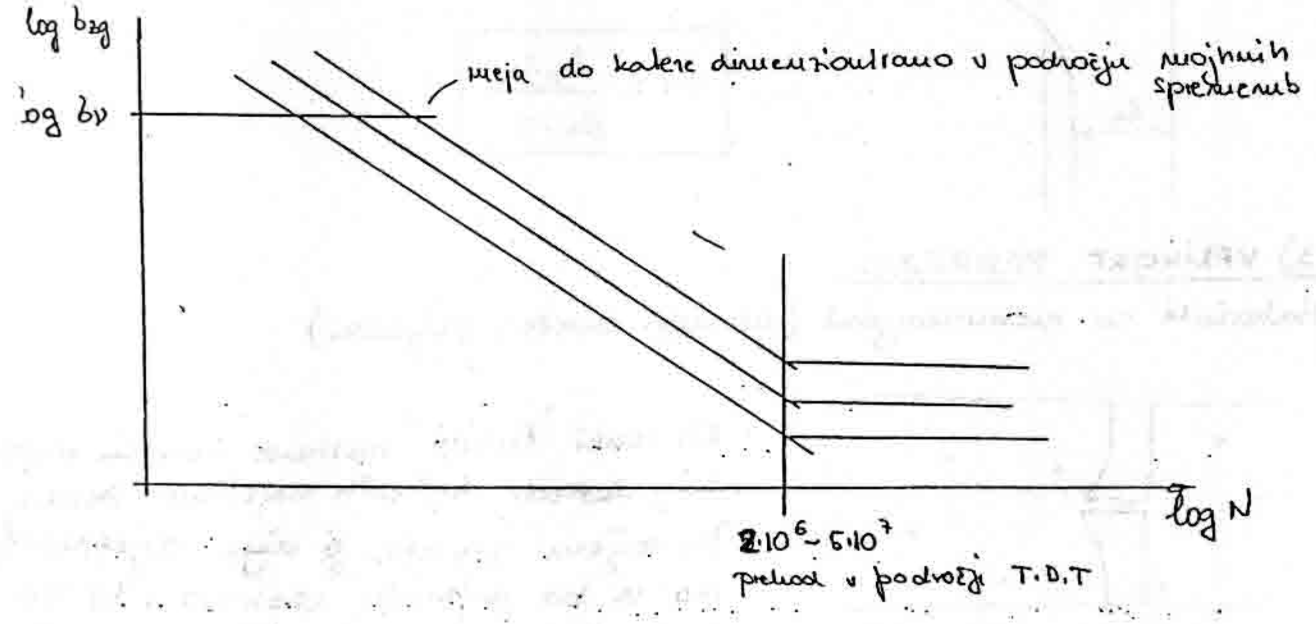
$$\boxed{\sigma_n \cdot \beta_k < \sigma_v \cdot b_1 \cdot b_2} \Rightarrow \sigma_{ObI} = \frac{\sigma_v \cdot b_1 \cdot b_2}{\beta_k} \;!!$$

$\sigma_n = \dfrac{\sigma_{ObI}}{S}$ ← varnost

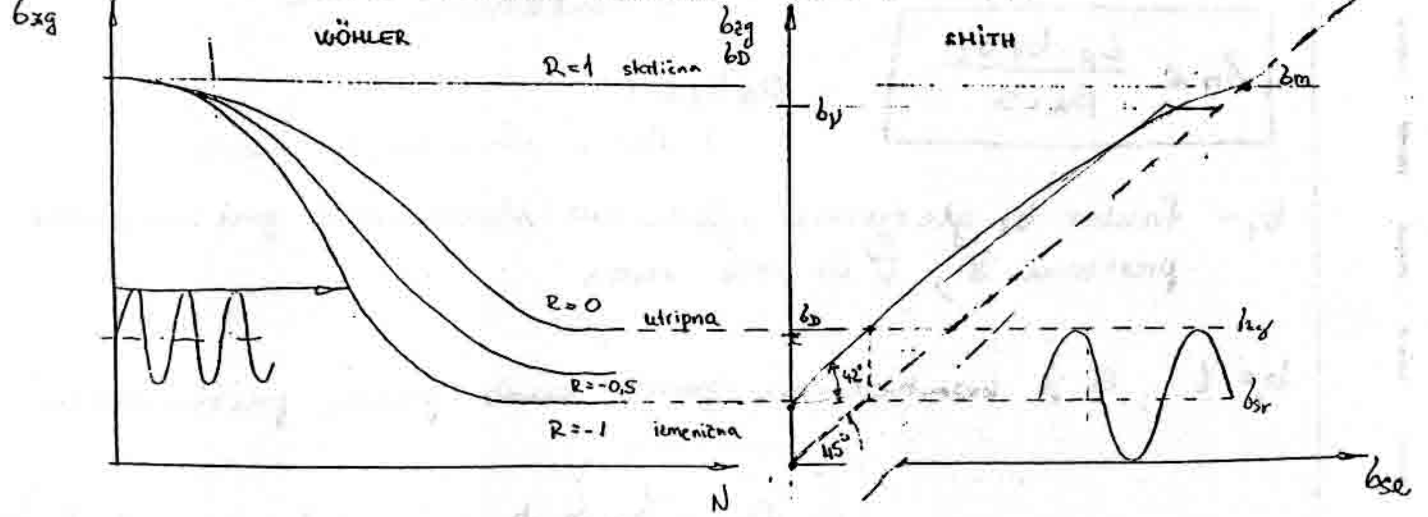
... utrujanje z deterministično obremenitvijo

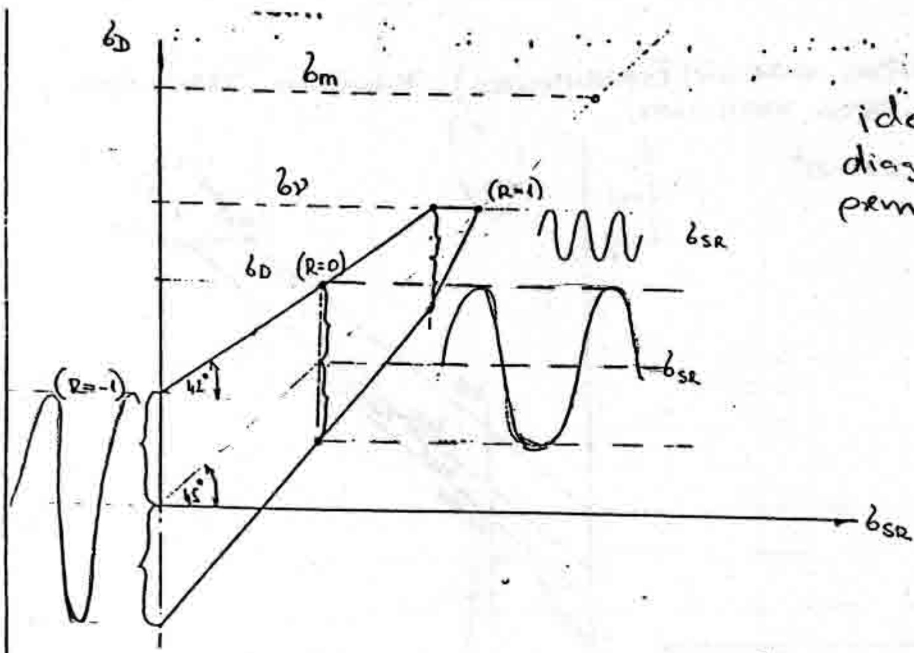


(1.) PRIKAŽI KAKO SE DOLOČI TRDNOSTNA MEJA PRI DETERMINISTIČNI OBREMENITVI!



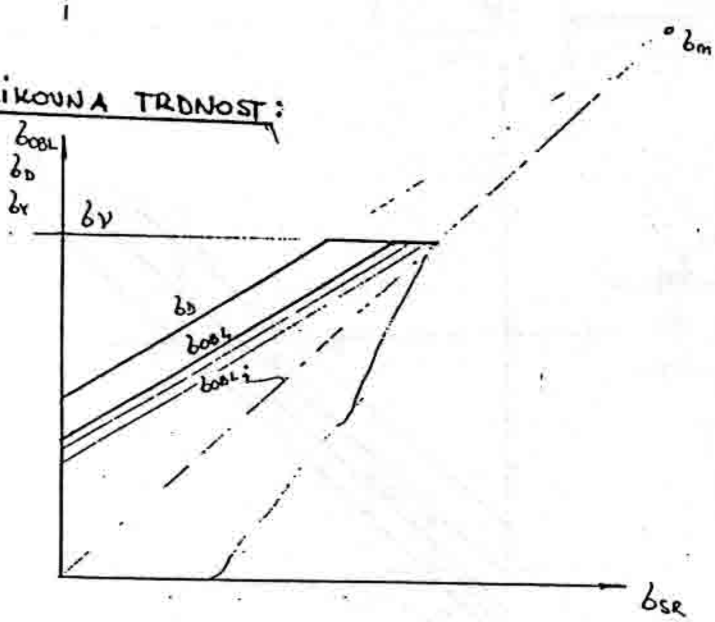
1) KAKO IZ WÖHLERJEVE KRIVULJE KONSTR. SMITHOV DIAGRAM!





idealizacija SMITHOVEGA diagrama. Potegnemo ravno premico pod kotom 42°.

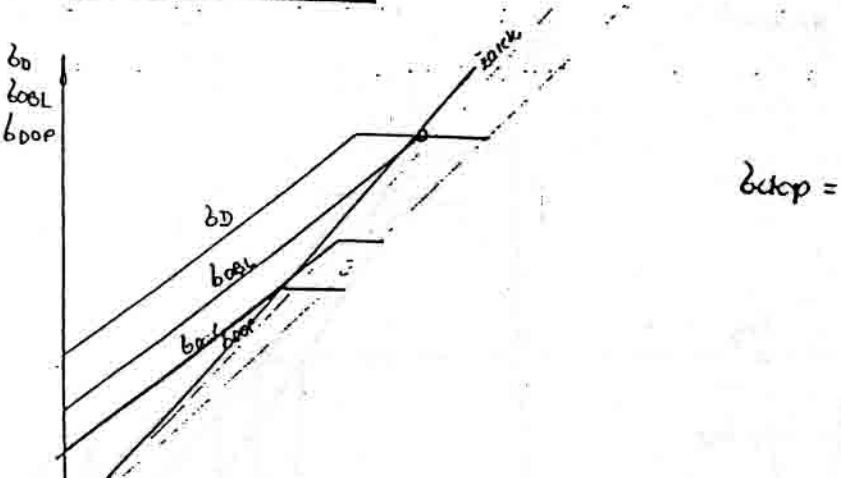
OBLIKOVNA TRDNOST:



$$\sigma_{OBL} = \frac{\sigma_D \cdot b_1 \cdot b_2}{\beta_K}$$

② KAKO IZ WÖHLERJEVE KRIVULJE DOBIMO SMITHOV DIAGRAM VRIŠI OBLIKOVN IN DOPUSTNO MEJO IN RAZLOŽI FAKTORJE b_1, b_2, S,

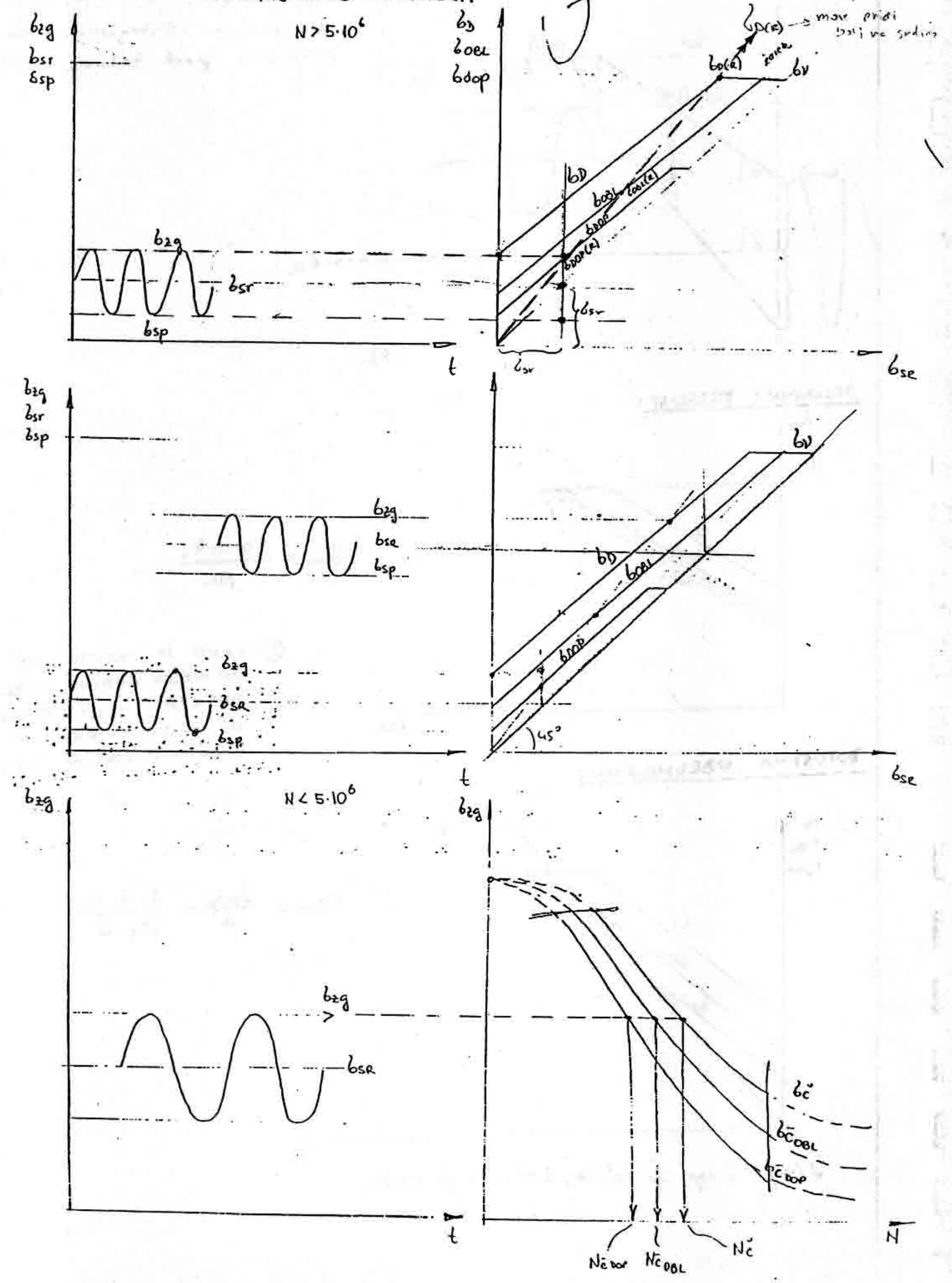
DOPUSTNA OBREMENITEV:



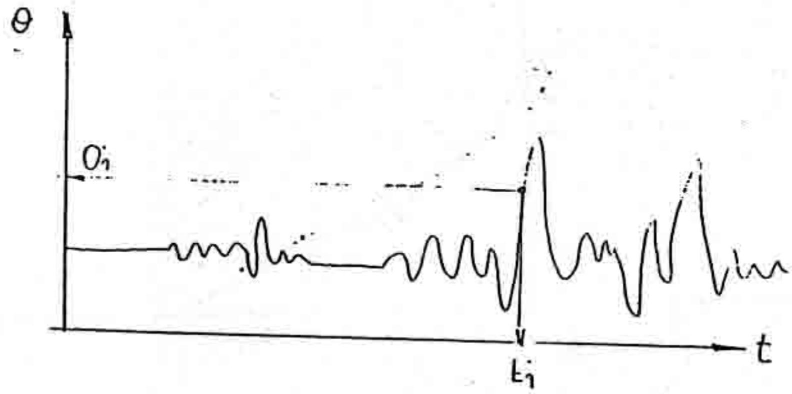
$$\sigma_{dop} = \frac{\sigma_{OBL}}{S} = \frac{\sigma_D \cdot b_1 \cdot b_2}{\beta_K \cdot S}$$

Linij σ_{dop} je toliko, kolikor je oblik

KAKO ZA DANO DINAMIČNO NAPETOST (OBREMENITEV) DOLOČIMO TRDNOSTNO, OBLIKOVNO IN DOPUSTNO MEJO NOSILNOSTI

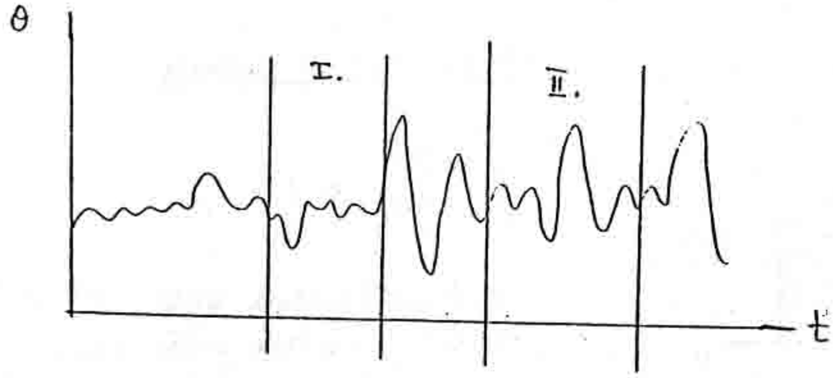


...ENJA DIMENZIJSKE PRIMERNOSTI PRI DINAMIČNI NAKLJUČNI OBREMENITVI:



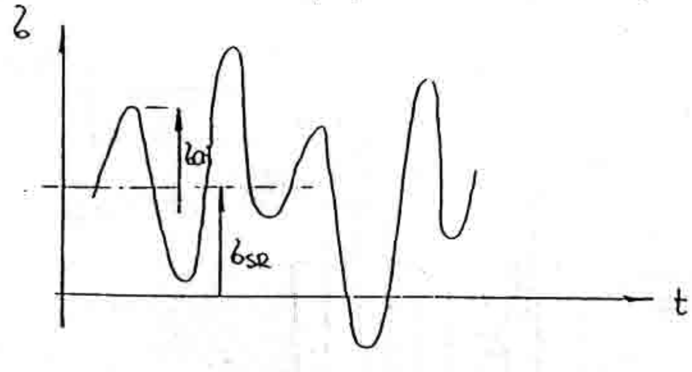
Postopek dimenzioniranja:
- obremenitev simuliramo na računalniku
- merjenje na podobnih konstrukcijah

Ugotavljamo:
- amplitudo obremenitve
- srednja vrednost
- število sunkov

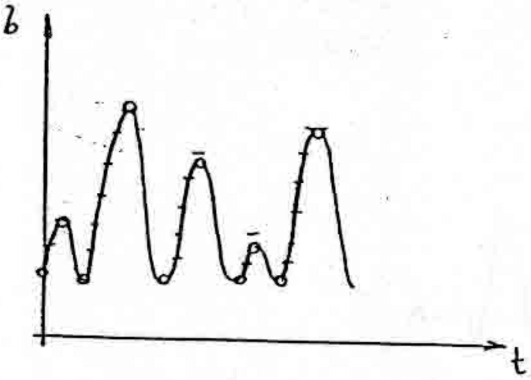


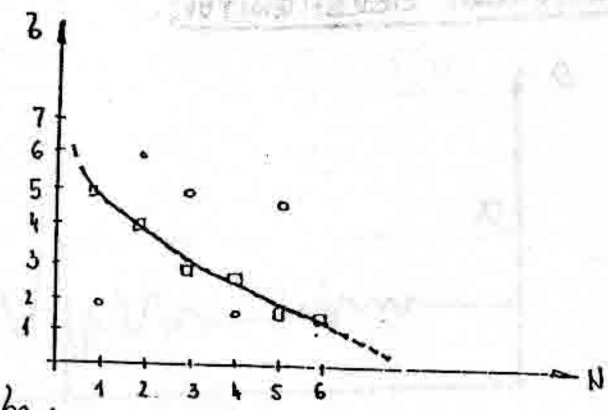
1.) I, II - vzorca obremenitvenega stanja
2.) preverimo ali sta vzorca stacionarna ali ergodična.

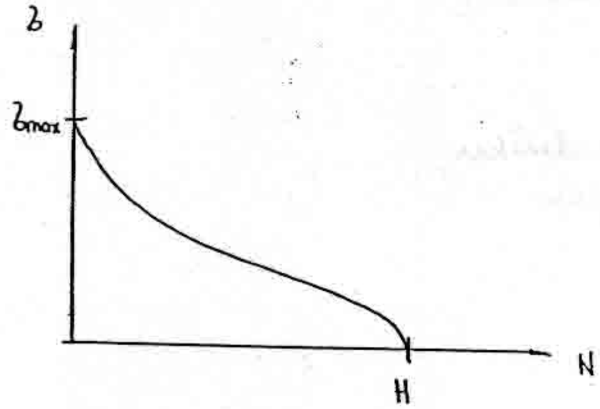
Kako preštejemo število sunkov:
- štetne metode
- dvoparametrsko štetje (velikost sunka b_{ai} + N_i)
- troparametrsko štetje (velikost sunka b_{ai} + b_{se} + N_i)



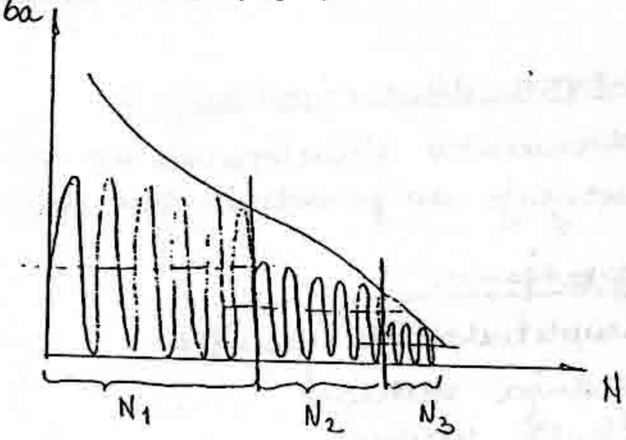
N_i - število sunkov

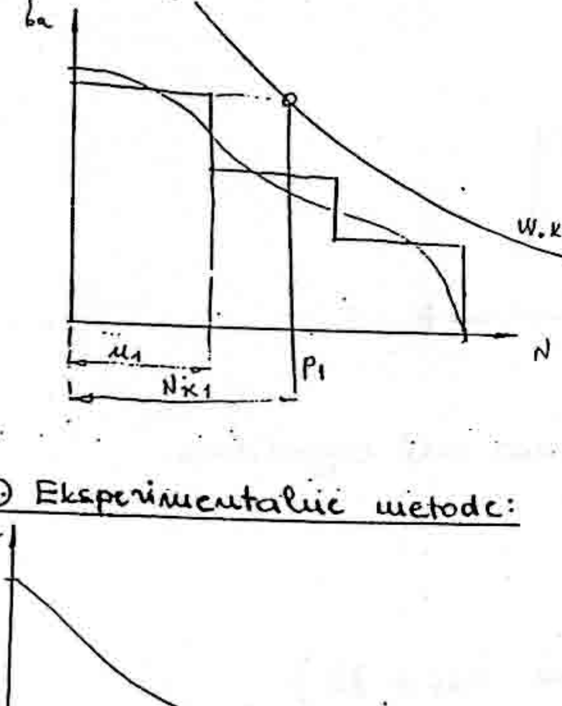






H-skupno število ciklov





① Analitične metode

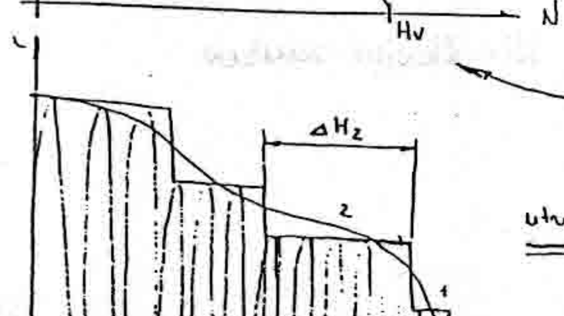
$$\sum_{i=1}^{3} \frac{n_i}{N_i} \lesseqgtr 1$$

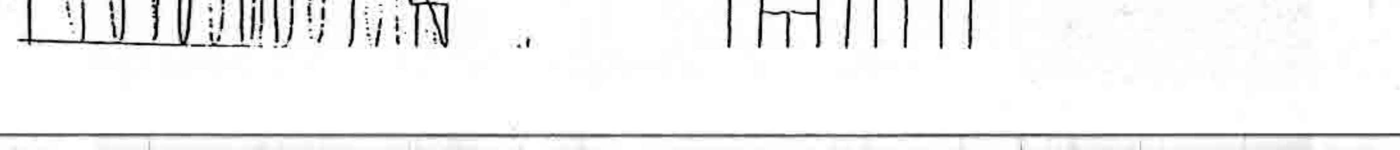
> 1 poškodba večja od krit. poškodbe

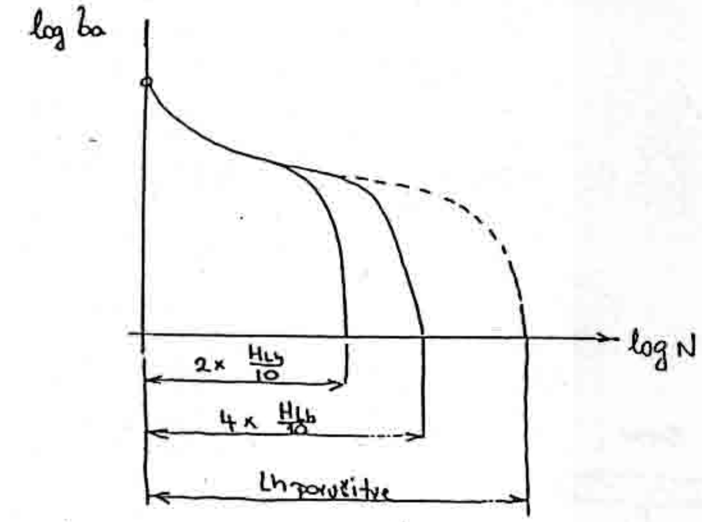
$= 1$ kritična poškodba

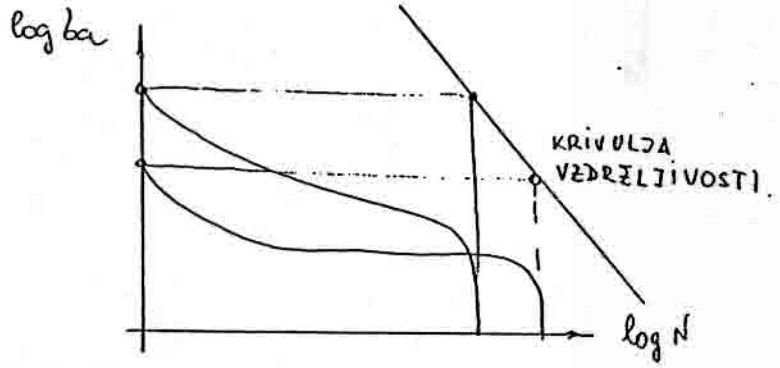
< 1 poškodba manjša od kritične poškodbe $\Rightarrow$ ZDRŽI.

② Eksperimentalne metode:







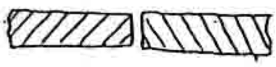


VARJENE KONSTRUKCIJE

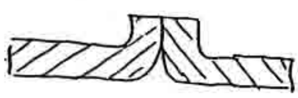
Več elementov varimo v nerazdružljivo zvezo

OBLIKE ZVARNIH SPOJEV:

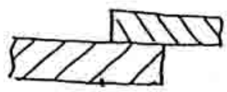
1.) soležni spoj:



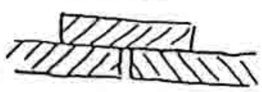
2.) soležni spoj s prirobom:



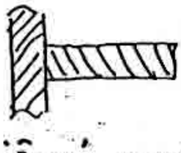
3.) prekrivni spoj



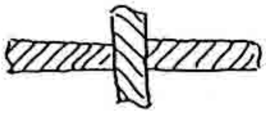
4.) zaplatni spoj



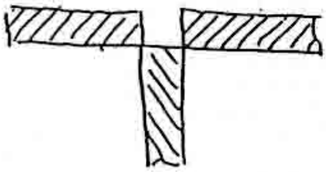
5) kotni spoj



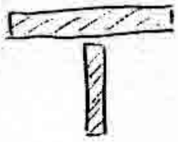
6.) križni spoj



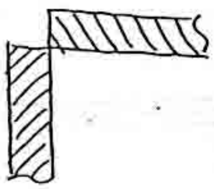
7.) Trodelni spoj T



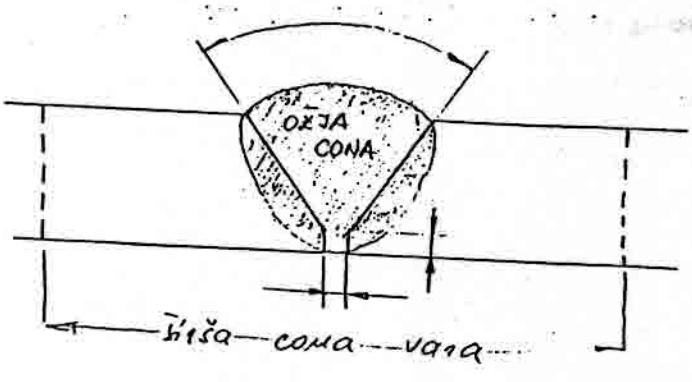
T spoj



8) Vogelni spoj



Varjenje:
- talilno → stalimo s pomočjo plamenskega gorika
- s stiskanjem → močno stisnemo oba dela → ↑T zaradi trenja → var
- hladno varjenje →
- s segrevanjem in stiskanjem → ravnočno v vroč. kopel in stisnemo pajamo lahko skupaj različne vare



OŽJI DEL: področje v katerem je bil material uležinjen

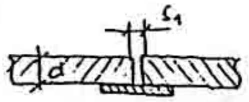
ŠIRŠI DEL: področje v katerem je material utrpel visoke spremembe temperature

PRIPRAVA ZVARNIH MEST

1.) zvar na privihu.

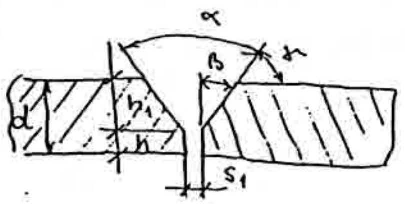
2.) zvar I

a) z zaščitno letvijo

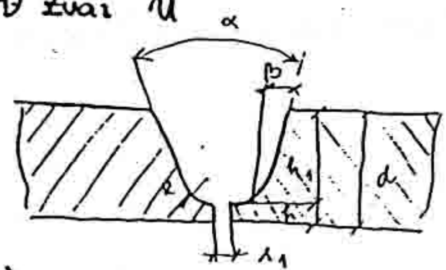


b) brez zaščitne letve => za I var

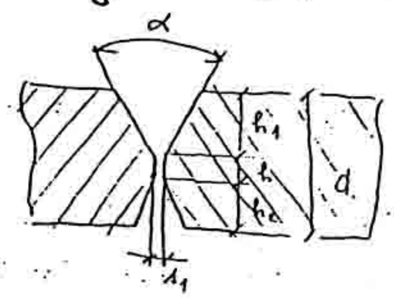
3.) zvar V



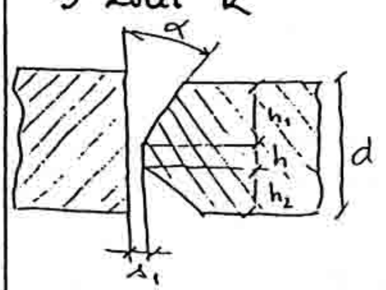
4.) zvar U



5.) dvojni V zvar ali X zvar



6.) zvar K



važne mere:

- širina špranje žleba (s_1)
- višina špranje (h)
- kot žleba (α)

DODAJNI MATERIAL:

- mora dobro povezati (kompatibilen na osnovni material)
- podoben osnovnemu materialu
- za en razred boljši kot osnovni mat.

Varimo brez ali z zaščitno cono. (zaradi oksidiranja)

Odvzem materiala delamo mehansk ne brusimo zaradi OT.

Morajo imeti določeno stopnjo ogljika, žveplo, fosforja in dušika. Uporabljati moramo pomirjene materiale.

Č. 0545 V

V - primeren za varjenje

Jekleni mat. za varjenje:

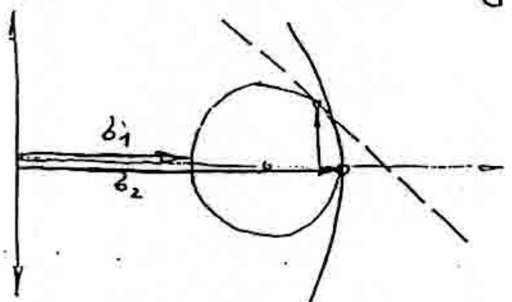
1) Č.0345, Č.0445, Č.0545 ; kemično, mehansko čistočo, σ_m, σ_T garantira proizvajalec.

2) Č.0360, Č.0460, Č.0560
Č.0461, Č.0561
Č.0462, Č.0562 ; kemično, mehansko čistočo, σ_m, $\sigma_T + \delta_v$ garantira proizvajalec

Č.--60 normaliz. material.
Č.--61 visokovredni material
Č.--62 mat. posebej odporen proti krhkemu lomu.

P-preveč:

Nastane nevarnost krhkega loma



razpoka v prečni smeri

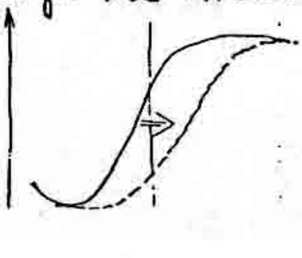
nastane razpoka v vzdolžni smeri zelo slaba možnost.

S-preveč

Nevarnost vročega loma ⇒ popusti zvarno mesto.

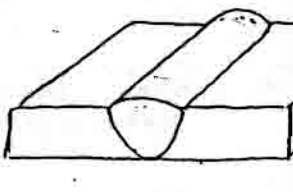
N-preveč

Material občutljiv na staranje. Čez nekaj let postane material krhek.

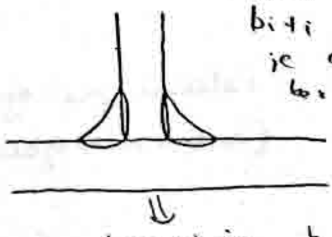


- soležni var:

soležni var:



kotni var:

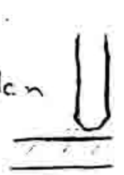


niti približno ne more biti S kvalitete. Težko je doseči tudi I kvaliteto, ker je koren nedostopen

S, II

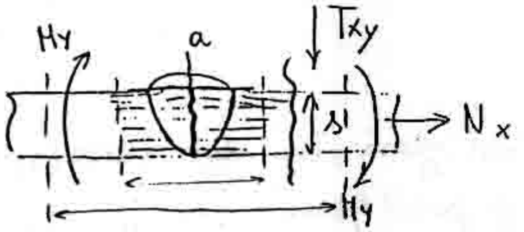
⇓

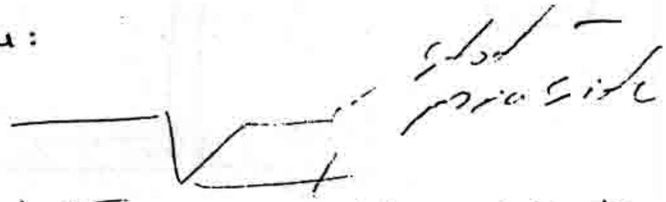
boljši je t var, ki je obdelan



Kje pride do obremenitve v varu:

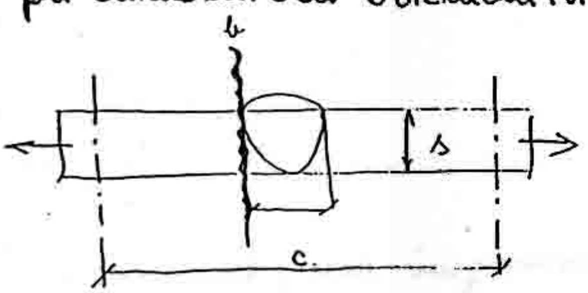
a) pri statični obremenitvi





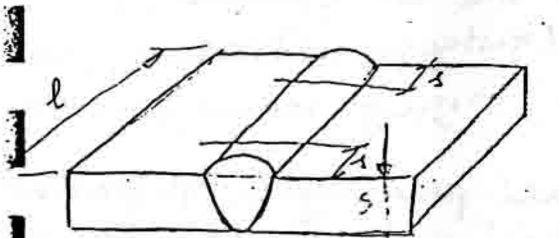
a) male verjetnost da pride do porušitve, ker je dodajni material boljši kvalitete od osnovnega materiala.

b) pri dinamični obremenitvi



b) Zelo velika verjetnost. Računati moramo z zareznim učinkom

c) Verjetnost mesta porušitve Osnovni material ji bil med varjenjem poškodovan.



$A_{zvar} = s * (l - 2s)$

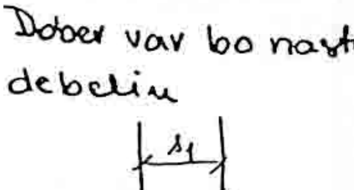
$l_{zv} = l - 2s$

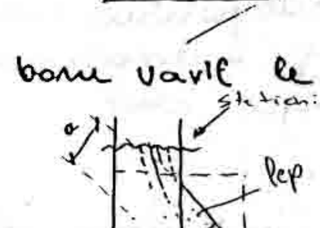
oz. če postrgamo za začetek in konec.

$A_{zvar} = s * l$

Ne kopičiti varov

Dober var bo nastal če bomo varili le pločevine enakih debelin



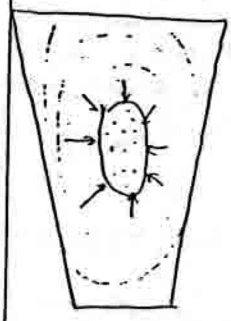


za dimenz.:

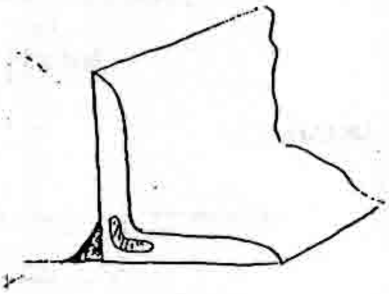
$l: l_{pl}, l - 2a$

a - dimenzija včrtanega trikotnika vara.

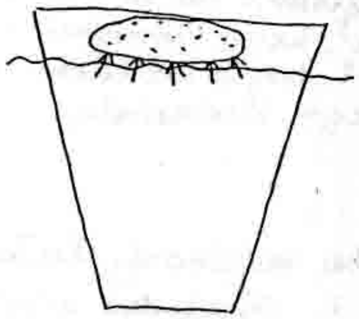
$A_{zvar} = s * (l - 2a)$



izločki prihajajo v cono kjer je še tekoče stanje, (nehomogeno struktura) nekontrolirano ohlajanje



nepomirjen material, neuporaben



izceja v jalovi glavi, ta del odrežemo in materijal je pomirjen.

Kvalitete varov: S, I, II.

S-kvaliteta: specialna kvaliteta, homogeni vari, brez razpok, brez napak zaradi začetka in konca varjenja. Koren vara izdolbe in ponovno zavarjen. Teme vara ne sme biti izbočeno. Var mora biti kontroliran po celotni dolžini (rentgen, ultrazvok). Varilec mora imeti izpit, ki velja pol leta, varjenje samo v horizontalni smeri.

I. kvaliteta: se zahteva za mirujoče ali premikajoče se pretežno statično obremenjene lahke konstrukcije in cevovode. Napravi se 100% radiografska kontrola. Varijo lahko le varilci z izpitom za določen položaj varjenja. Manjše napake so dopustne, ne sme pa biti razpok in večjih vključkov.

II. kvaliteta: velja za zvarne spoje, ki so izpostavljeni majhnim obremenitvam, za montažne konstrukcije in sestavne dele, za katere niso postavljene posebne tramostne zahteve. Varilec mora imeti izpit za varjenje v določenem položaju.

ti vari imajo atest

∅ ta var nima atesta

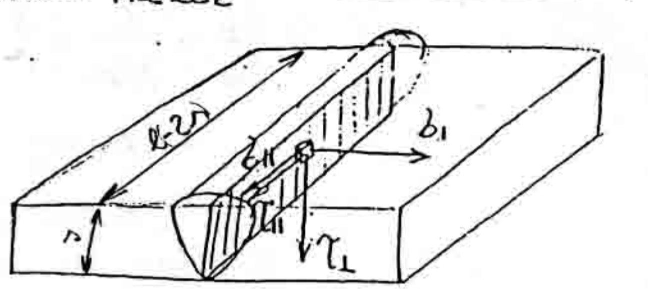
ATEST → dokument v katerem pooblaščena organizacija določi, da je ta var tipa S, I, II

CERTIFIKAT → potrdilo za kvaliteto, izda se če so norme dosežene, pa te norme niso zapisane v standardu.

… SOLEŽNIH VAROV:

KRITIČNI PREREZ

SOLEŽNI VAR: ⊣



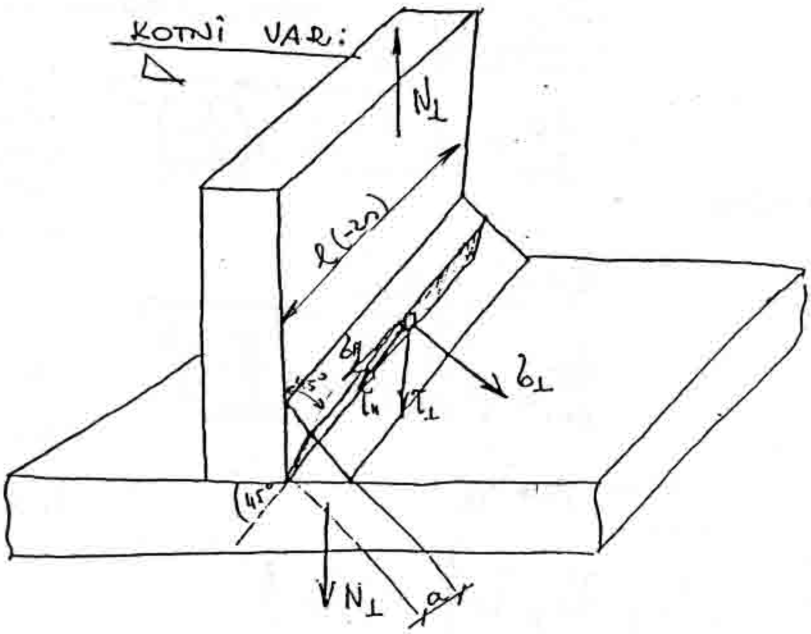
σ_1… normalna napetost prečno na dolžino vara

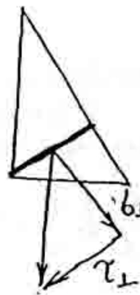
$\tau_\perp$… strižna napetost pravokotno na žvar

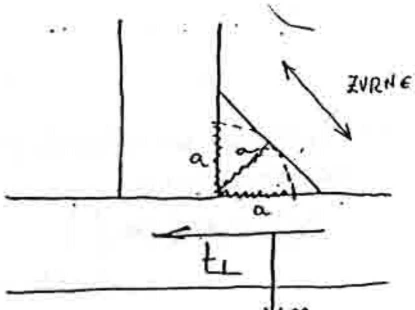
τ_{II}… strižna napetost vzdolžno na žvar

σ_{II}… normalna napetost vzdolžno na žvar

KOTNI VAR: ◁

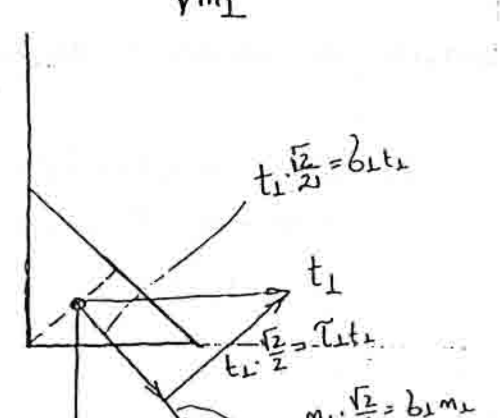


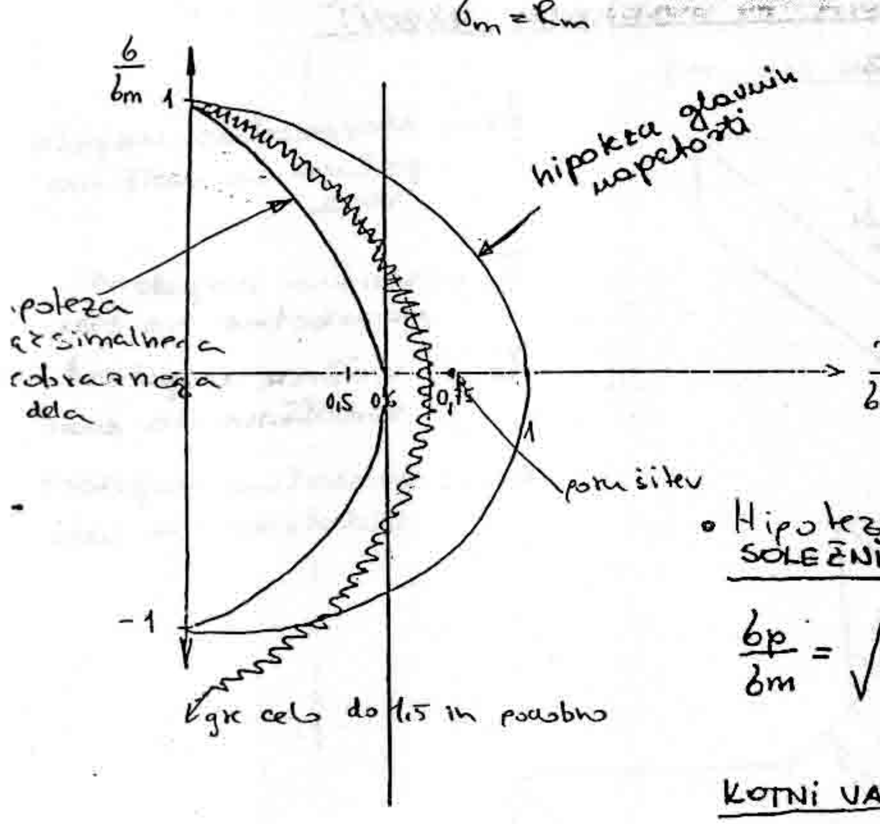




$$t_\perp = \frac{T}{a \cdot l_{zv}}$$

$$m_\perp = \frac{N}{a \cdot l_{zv}}$$





Hipoteza glavnih napetosti

1.) $\frac{\sigma_p}{\sigma_m} = \frac{\sigma}{2\sigma_m} + \frac{1}{2}\sqrt{\left(\frac{\sigma}{\sigma_m}\right)^2 + 4\left(\frac{\tau}{\sigma_m}\right)^2}$

+ pogoj

$\tau \leq 0{,}6\ \sigma_m$

ni dobra, ker je premalo kritična

- Hipoteza maks. preobraznega dela

SOLEŽNI VAR:

$$\frac{\sigma_p}{\sigma_m} = \sqrt{\left(\frac{\sigma}{\sigma_m}\right)^2 + 3\left(\frac{\tau}{\sigma_m}\right)^2}$$

V praksi se izkaže, da je za soležne var bolje vzeti 3, za kotne var pa 1,8.

KOTNI VAR:

$$\frac{\sigma_p}{\sigma_m} = \sqrt{\left(\frac{\sigma}{\sigma_m}\right)^2 + \lambda\left(\frac{\tau}{\sigma_m}\right)^2}$$

$\sigma_p = \sqrt{\sigma_\perp^2 + 1{,}8(\tau_\parallel^2 + \tau_\perp^2)}$

$\sigma_p \leq \frac{\sigma_{0\check{z}L} \cdot b_1'}{S}$ (spl. stroj.)

$\sigma_p \leq \sigma_{dop} \cdot b_1'$ (jekl. konstr.)

namesto 3 uvedemo $\lambda = 1{,}8$ in dobimo pravi rezultat, ki v negativnem delu se malo odmika

$\lambda = 1{,}8$

$$\{0\} \to \{\sigma\} \to \{\sigma_\perp, \sigma_\parallel, \tau_\perp, \tau_\parallel\} \to \{\sigma_p\}$$

$\sigma_p \leq \sigma_{dop}$

$\sigma_{dop} = \frac{\sigma_v \cdot b}{S}$ STATIČNA OBR.

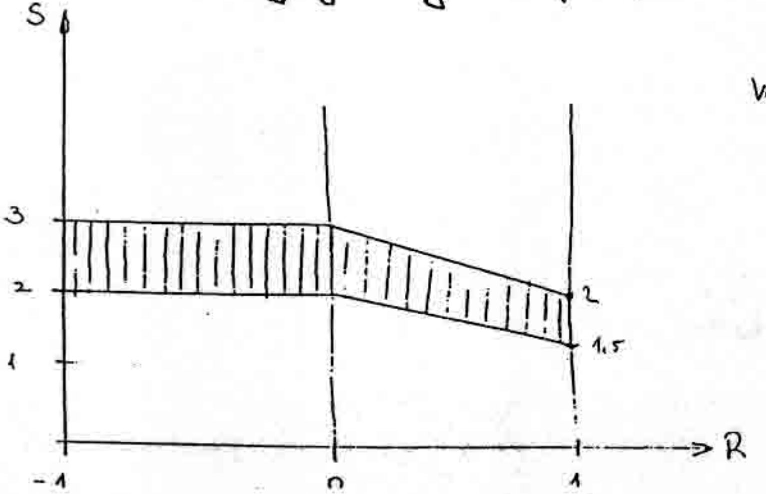
$\sigma_{dop} = \frac{\sigma_{D\check{z}} \cdot b_1 \cdot b_2}{\beta_k \cdot S}$ DINAMIČNA OBR.

Korigirano nosilnost pri kotnem varu

$b_1' = 0{,}8 \cdot \left(1 + \frac{1}{a}\right)$

a[mm]

Za splošno strojegradnjo ni predpisanih standardov za varnost

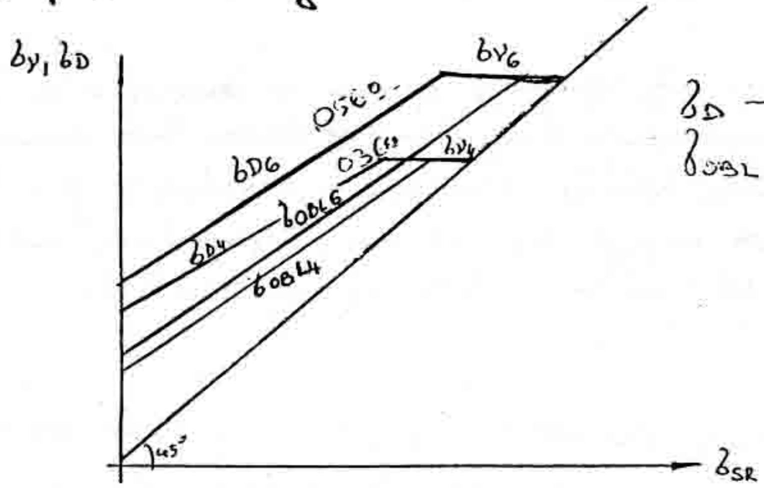


varnost ugotovljena s poizkusi

S = od 1.5 naprej

VPLIV RAZLIČNIH PARAMETROV NA NOSILNOST ZVAROV.

a) Vpliv osnovnega materiala na nosilnost zvarov:

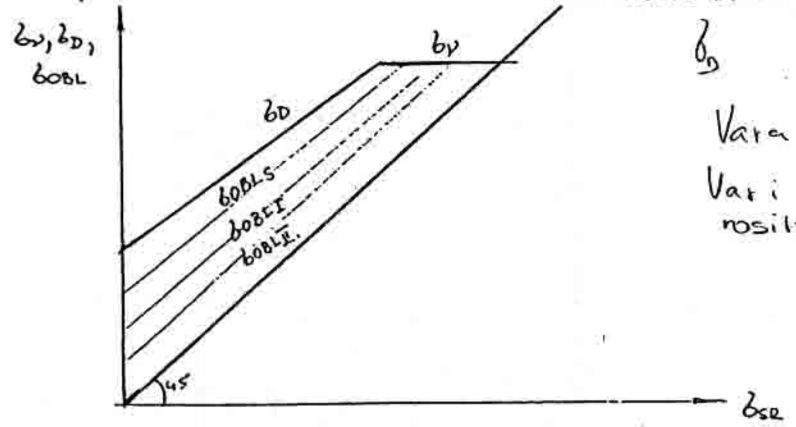


$\sigma_D \to \sigma_y$

σ_{OBL}

Za dinamične obremenitve se ne splača uzeti boljših materialov, ker so občutljivi na napake.

b) vpliv kvalitete vara na nosilnost:

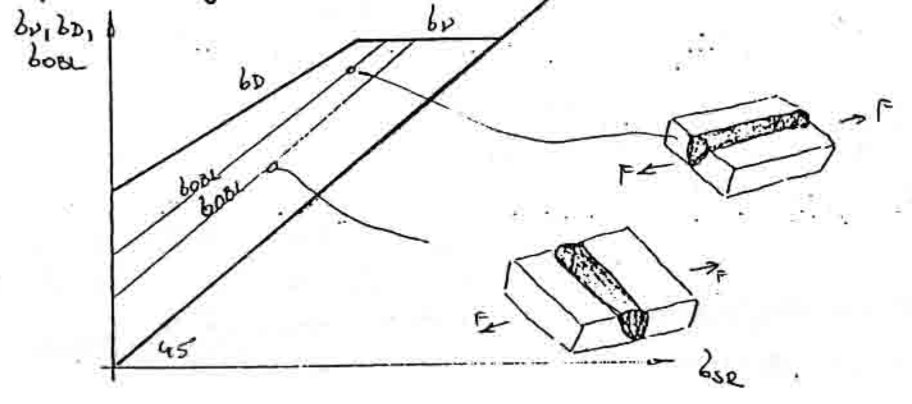


σ_D

Vara ∅ ni na grafu

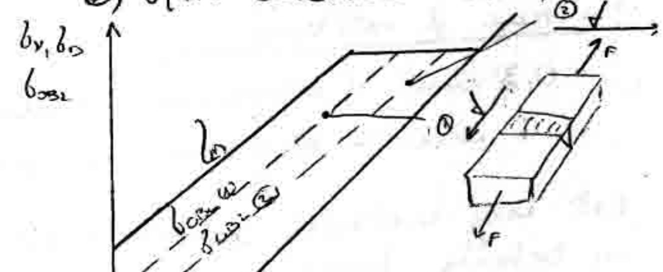
Vari ∅ kvalitete ne morejo biti nosilni.

c) vpliv lege vara na nosilnost:



d) vpliv vrst vara na nosilnost:

e) vpliv obdelave vara na no



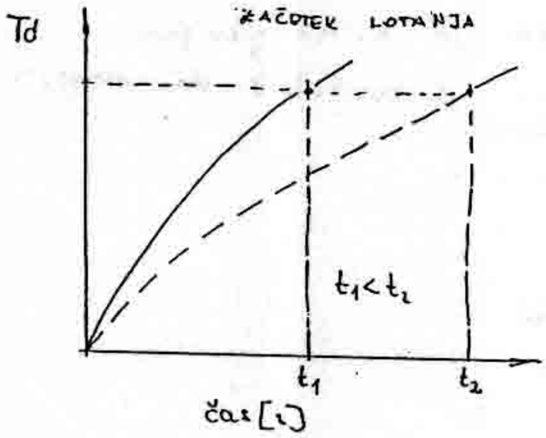
LOTANI SPOJI

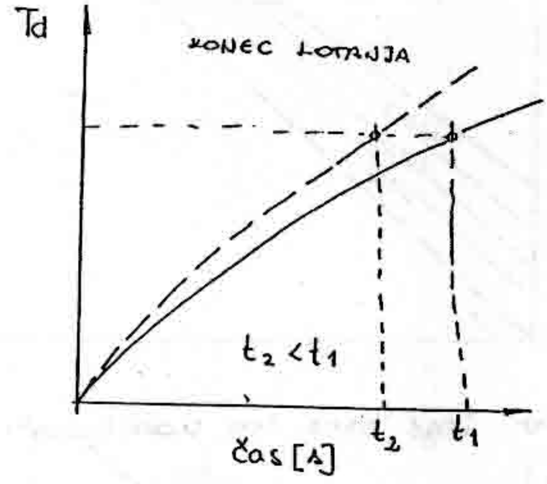
Lotanje je nerastavljiva zveza. Je spajanje delov z dodajnim materialom - lotom, ki ima popolnoma drugačno sestavo kot osnovni material in ima vedno nižje tališče. Osnovni material se pri lotanju ne raztoli, ampak se ogreje do "delovne temperature" tališča lota. Osnovni material naj bo kemično čist in mehansko čist.

Vrste lotov:

- mehki loti ($T_T = 350°$ obratujejo do $60°$) za jeklo so to zlitine jeklo in kositra
- trdi loti ($T_T = 450°$ " do $250°c$) za jeklo → srebro, medenina; za trše kovine → silicij, aluminij, kositrove zl.

Za lotanje karbidnih trdin na žilave podlage





Td - delovna temp.
t_1 - temp. lota
t_2 - temp. produkta

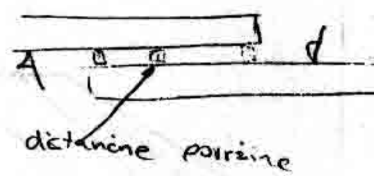
Način dodajanja raztaljenega lota:

- z izrabljanjem kapilarnosti v regi
- z zalivanjem

Pri plastičnih deformacijah se molekule gnetejo in zaradi tega lot popusti.

Distanca je velikost rege:

- = 0,3 mm - dinamično obremenitev
- ≈ 1 mm - statično obremenitev



Lot naj ustvari zadostno velike adhezijske sile med materialom in lotom. Lot je sposoben prenašati samo STRIŽNE obremenitve če nastopi kakšna normalna napetost, lotni spoj ne nosi več.

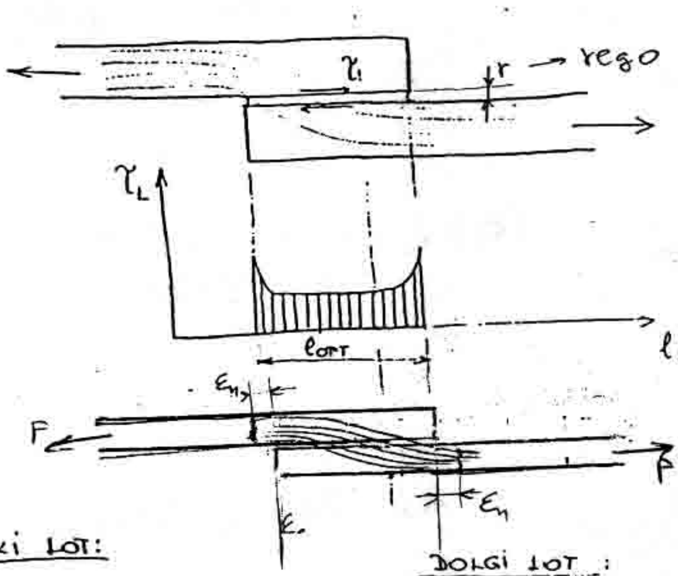
Prednosti lotanih spojev:

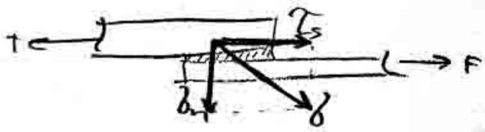
- spajamo različne materiale med sabo
- osnovni material ne talimo (ni toplotnih sprememb)
- priprava, spajanje enostavna

Slabosti lotnih spojev:

- kemično in mehansko čistk površine
- razmeroma nizka trdnost → slabo za dinamične obremenitve
- uporabni samo pri nižjih temperaturah
- komplicirana priprava pločevine

- Lotani spoj mora biti: pripravljen in dobro oblikovan tako da v njem nastopajo samo strižne napetosti.
- Lot je kovinski material, ki strig nosi, nateg pa zelo slabo

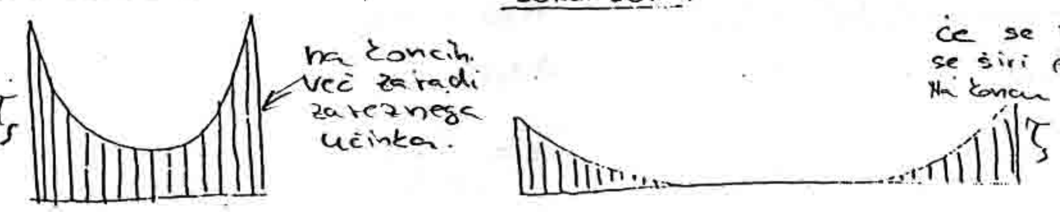




pločevini se podaljšata zaradi sile, lot prevzame deformacijo zato ima strižna napetost obik. črke U ⇒

KRATKI LOT:

DOLGI LOT:



Če se razpoka začne širit se širi proti drugemu koncu na koncu pridemo do ničle dol lope.

$$l_{OPT} = (6 \div 12) \cdot s$$

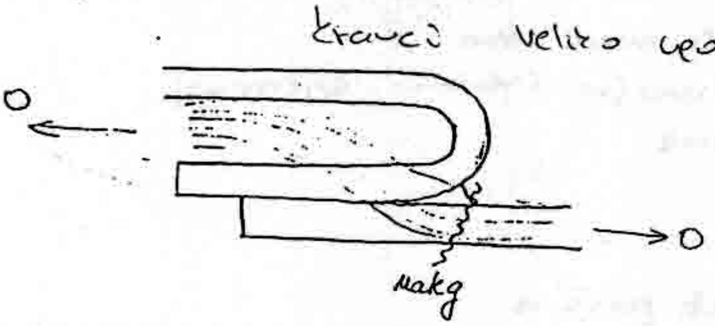
s - debelina pločevine

Kako dobiti najboljši pretok silnic?

a)

b)

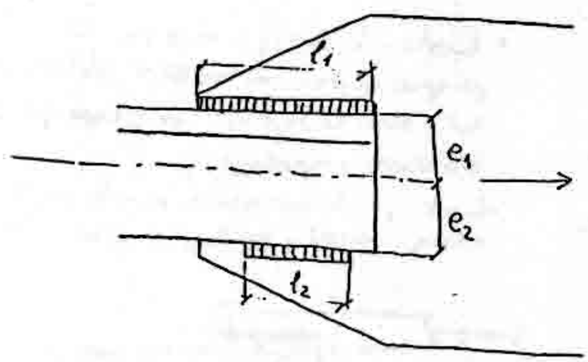
Kranci veliko uporabljeno



takšen spoj ne nosi nič

PRINCIP DIMENZIONIRANJA: (velja za var kot za lot)

VAR:

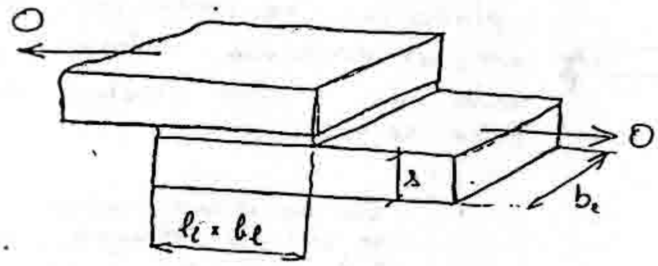


Nosilnost osnovnega materiala = nosilnosti priključka

$$\frac{l_1}{l_2} = \frac{e_1}{e_2}$$

$$(l_1 + l_2) = \frac{A_{OM} \cdot \sigma_{dop\,O.M.}}{a \cdot \sigma_{dop\,zv.}}$$

LOT:



$$A_{OM} \cdot \sigma_{dop\,OM} = A_{lot} \cdot \tau_l$$

$$A_{OM} = b \cdot s$$

$$A_{lot} = l_l \cdot b_l$$

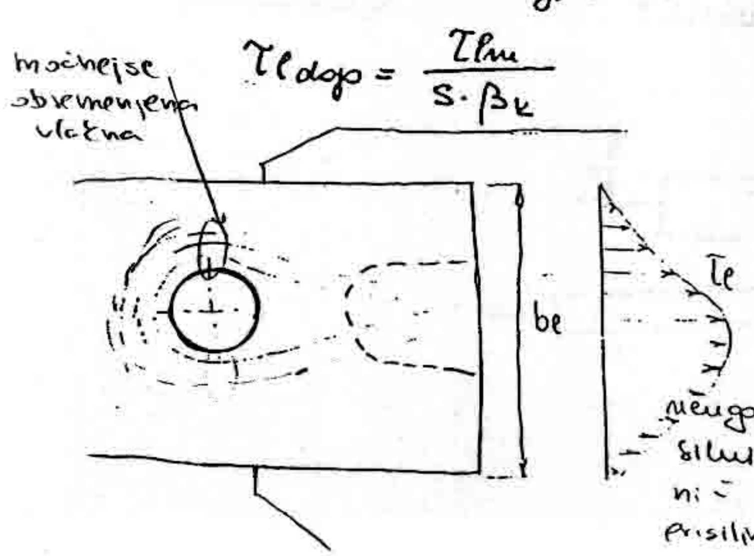
$$\tau_l = \frac{O}{b_l \cdot l_l}$$

$$\tau_l \leq \tau_{l\,dop}$$

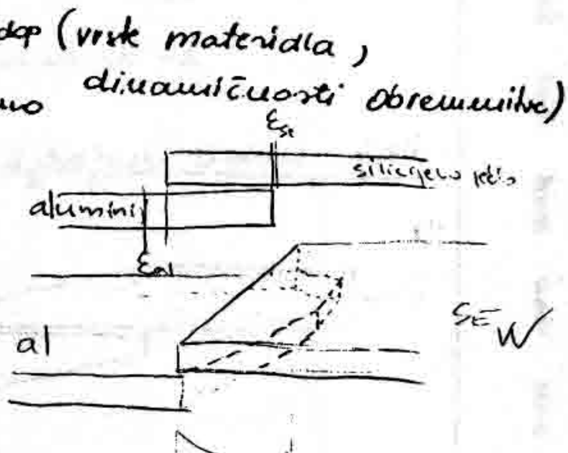
$\tau_{l\,dop} = \tau_{l\,dop}$ (vrste materiala, dinamičnosti obremenitve)

Če dolžina lota ni optimalna, potem imamo konice napetosti. Takrat je:

$$\tau_{l\,dop} = \frac{\tau_{lm}}{S \cdot \beta_k}$$



neugodna razporeditev silnic, tisti del ki ni~~č~~ ne nosi vzamemo ven. Tako prisilimo silnice, da gredo po zunanjih straneh



Slabši material odrežemo in tako izboljšamo konstr.

LEPLJENI SPOJI: → umetne mase, ki se jih dodaja v tekočem stanju

Dodajni material so lepila. Lepljenje je adhezijsko spajanje konstrukcijskih elementov. Osnovni material ne utrpi nikakršnih toplotnih obremenitev. Lepimo lahko različne materiale. Nosilnost spojev je odvisna od deformabilnosti obeh lepljenih materialov.

LEPILA:

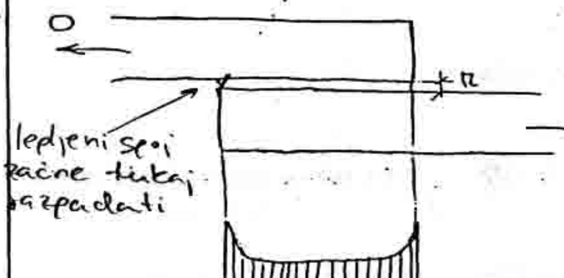
So kemične spojine, ki so zgrajene tako da imajo zelo dolge vlaknaste molekule z dvema lastnostma:
- natezna trdnost vlakna naj bo zadosti velika ($20 \div 80 \frac{N}{mm^2}$)
- z prostimi valenčnimi vezmi dobro poveže lepilo z osnovnim materialom.

1) Enokomponentna lepila: (fenolne smole) so lahko v raztopini in se toplo loči od aktivne komponente med utrjanjem spoja. Vežejo s pomočjo vlage v zraku. Podvrženo k staranju.

2.) Dvokomponentna lepila: (osnovna masa + trdilec) Problem kontroliranja vezave. Če je vezava hitra se ustvarjajo dolga vlakna. Trdilec je kem. spojina, ki povzroči polimerizacijo. 20°C

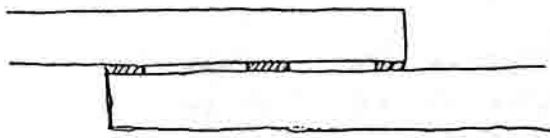
3.) Trokomponentna lepila: (osnovna masa + trdilec + katalizator) S katalizatorjem kontroliramo vezavo.

SLABOSTI:
- zahteven tehnološki postopek
- oblikovan mora biti, tako, da nosi samo strižne napetosti

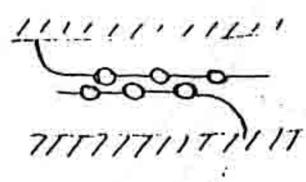


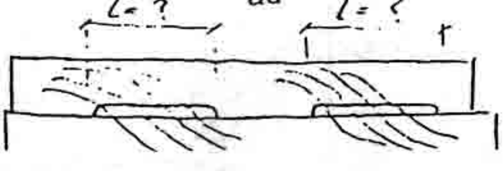
čim manjša rega ⇒ boljša nosilnost
0,3 - 0,5 mm

Razbijanje dolžine in držanje rege:
- z distančnimi pločevinami



Lepilo naj nosi

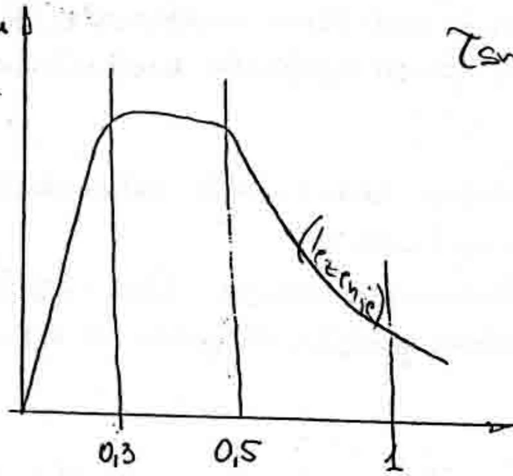




VPLIVI NA LEPLJENE SPOJE

... LEPLJENEGA SPOJA IN TEMPERATURE NA PORUSNO TRDNOST SPOJA:

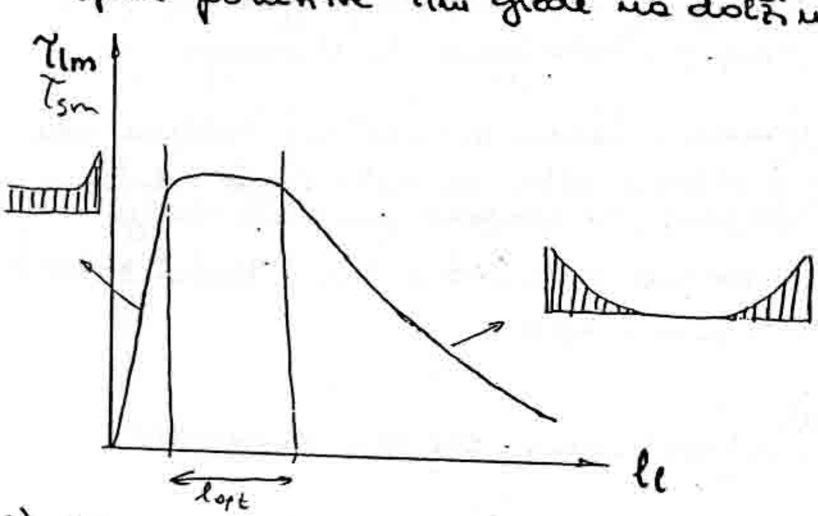
a) vpliv porušitve τ_{lm} na širino rege:



$\tau_{sm} \rightarrow$ strižni porušni

SLABOST:
- problem izolatorja → naelektriten → preskok iskre

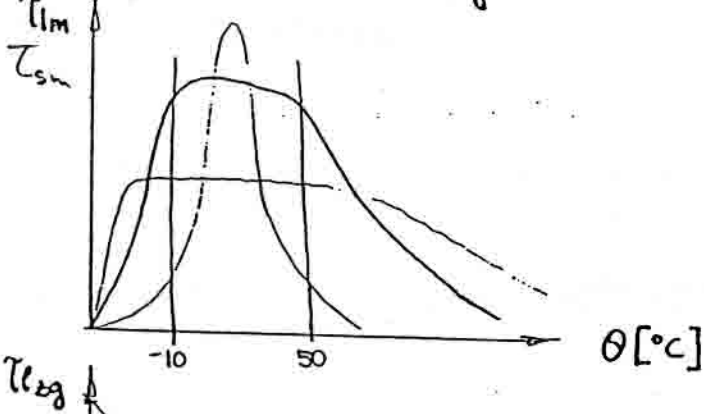
b) vpliv porušitve τ_{lm} glede na dolžino lepljenega spoja:



$$l_{opt_e} = 0{,}2 \cdot b_v \cdot (s^2+1)$$

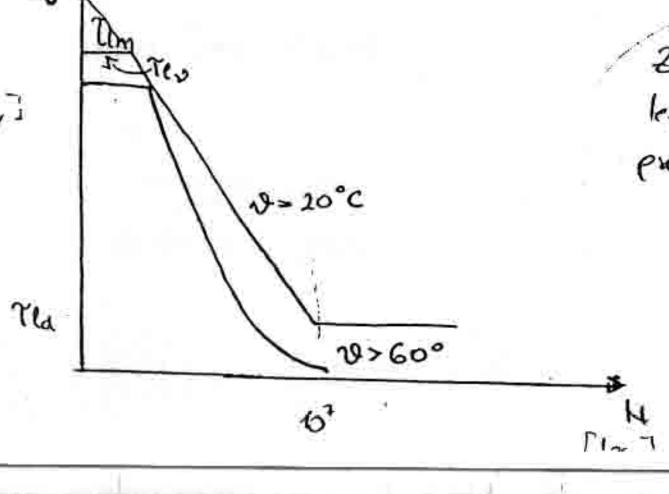
s - deb. pločevine

c) vpliv porušitve τ_{lm} glede na temperaturo

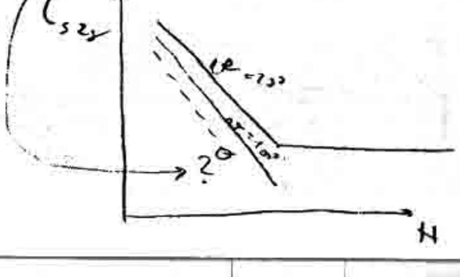


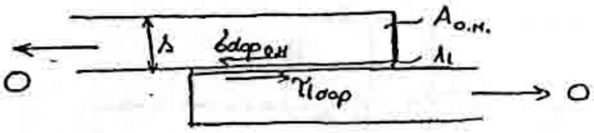
$\Theta < -10$; nevarnost krhkega loma

$\Theta > 50$; nevarnost lezenja (popuščanje notranjih sil s časom)



Za nižje temperature je težko doseči kjer je preobrat v TDT





$$A_{o.H.} \cdot \sigma_{dop\,o.H} = A_L \cdot \tau_{Ldop}$$

$$\tau_L = \frac{O}{A_L}$$

$$\tau_L \le \tau_{Ldop}$$

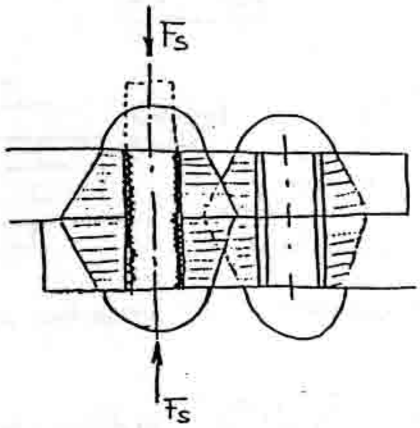
$$l_{opt} = f(\tau_c)$$

$$l_{opt} \doteq 0{,}2 \cdot b_v \cdot (s^2+1)$$

KOVICE IN KOVIČENI SPOJI:

Je pomišna zveza dveh ali več elementov

PRAVILO: istočasno se vrta v oba dela.



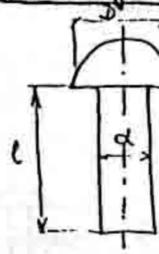
Toplo zakovanje: Ko se kovina ohlaja se kovica krči in nastane spenjalna sila F_s in ta povzroči v stiku osnovnih materialov trenje
$d_k > 10mm$ segreta kovica $\approx 850°C$

Hladno zakovanje:
Imamo samo preddeformacijo
$d_k < 10mm$

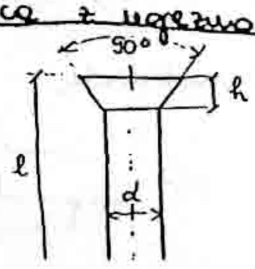
$F_s = f(l_{kovice}$, podajnosti osnovnega materiala)

OBLIKE KOVIC:

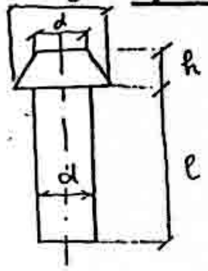
1) Kovica s polkroglo glavo:



2) Kovica z ugreznjeno glavo:



3) kovica s trapezno glavo:



4) Kleparske kovice:

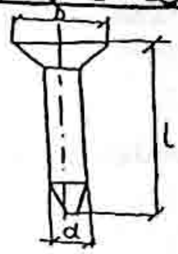
a) s polokroglo glavo 

b) z ugreznjeno glavo 

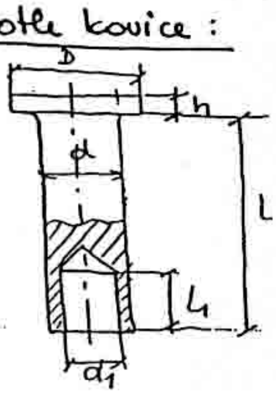
c) z lečasto glavo 

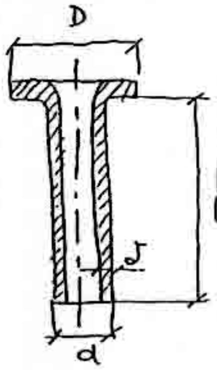
d) s ploščato glavo 

5.) Jermenske kovice:

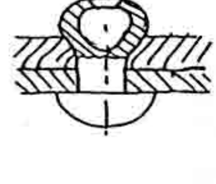


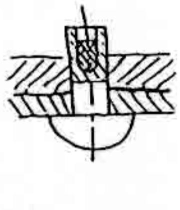
6) Votle kovice:

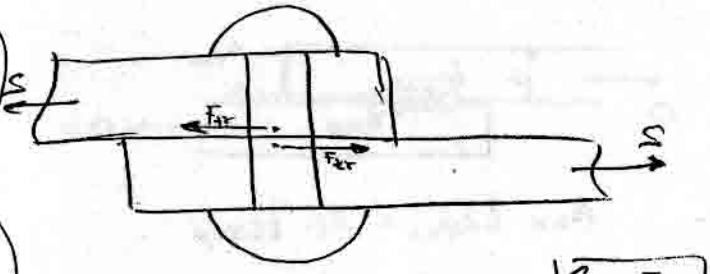




7) Eksplozijska kovica:





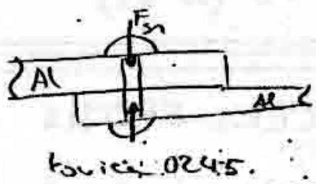


$\boxed{S < F_{tr}}$

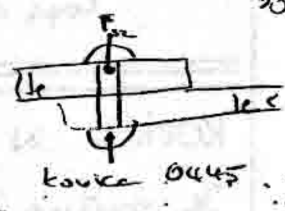
F_s → spenjalna sila, ki povzroči silo trenja

F_s (ϑ_{seg}, l, d, material kovice, material pločevine)

kovice iz ogljikovega konst. jekla → 0245, 0445

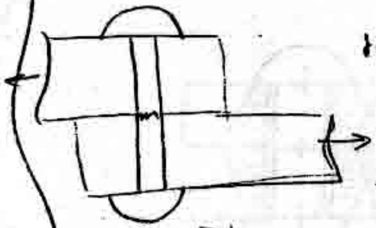


kovica 0245.



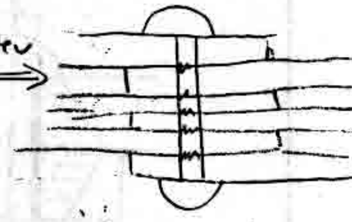
kovica 0445.

$\boxed{F_{s1} < F_{s2}}$

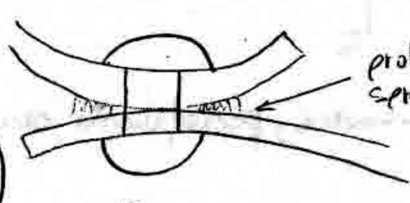


rešitev ⇒

kovica bi verjetno počila (zaradi krčenja)



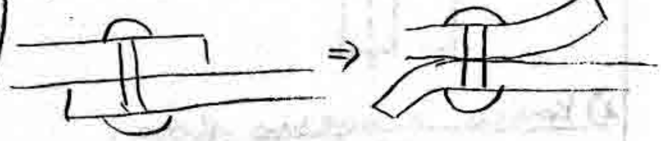
problem, ker nastane špranja ⇒ korozija



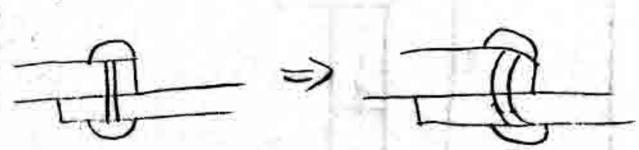
ne poznamo

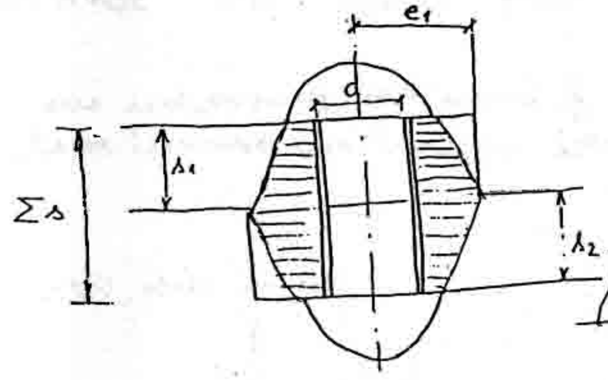
$F_{tr} = (F_s)\mu$

preveč materiala



premalo materiala

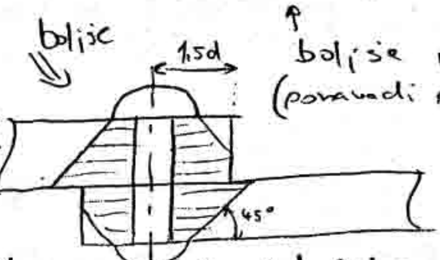




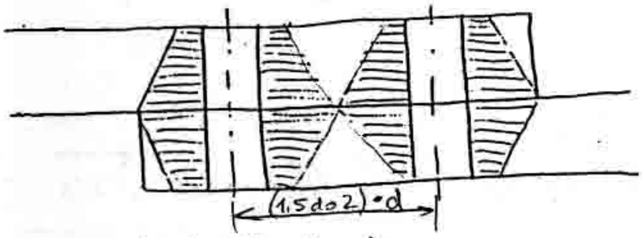
deb. kovice:

$d = \sqrt{5 \cdot s} - 0{,}2$ (cm) } PO

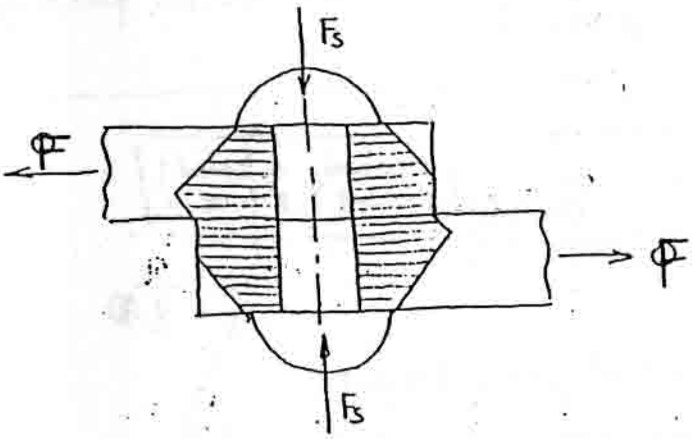
boljše je uzeti tanjše ploče (poravnati približno enako debele)



Če imamo več kovic, mora biti med njimi toliko prostora, da se razvijejo stožci tlačnih napetosti oz. se stožci tlačnih napetosti ravno malo prekrivajo.



DIMENZIONIRANJE KOVIC:



$\int_{A_{tl}} \sigma_{tl} \, dA_{tl} = F_s$

$0 \leq F_s \cdot \mu_A$ } PO

μ_A – izmerimo

$F_s = ?$

Tak preračun ni dober, ker ne poznamo specialne sile

$F_s = f$ (materiala kovic in osn. materiala, dolžine kovice, temperatur zakovanja, prekritosti stožcev)

Pri dimenzioniranju:
- strižno napetost vzamemo kot merilo (navidezni strig)
- obremenjeno pa je na bočni tlak

navidezni strig:

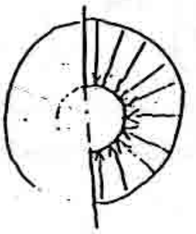
① $\tau_s = \dfrac{F}{n \cdot m \cdot \frac{\pi d^2}{4}} \leq \tau_{s\,dop}(\ldots)$ — preizkusili na trgalnem stroju } PO

n – št. kovic

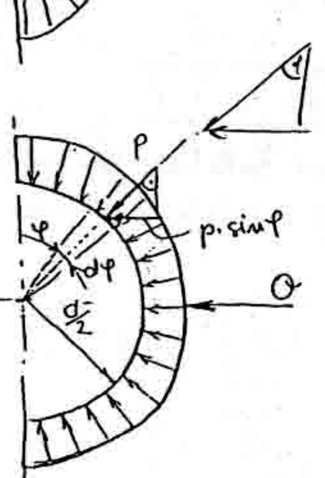
m – število strižnih ploskev

$F_{tr} = \mu_m F_s$ μ_m – st. obr. $\tau \leq \tau_{s\,dop}$

$\tau_{s\,dop}$ (μ, material kovice (1), m, dolžina kovice, debelina pločevine (2), osnovni material (3)) v kežnjo nakesno vstavimo (boćna obremenitev) než zatič ali sornik.



č je luknja polna je bočni tlak pravokoten na površino ki se kovica naslanja na osnovni mat.



$$\Phi = \int_0^{\pi} (p\cdot\sin\varphi)\cdot\frac{d}{2}\cdot l\cdot d\varphi$$

r

površina izven lista

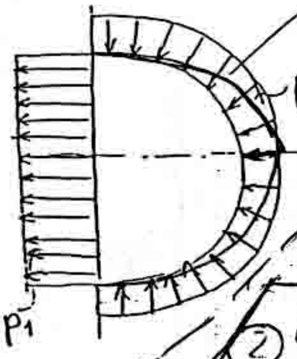
r dφ

$$\Phi = p\cdot d\cdot l$$

lok na katerega tlak deluje

II O

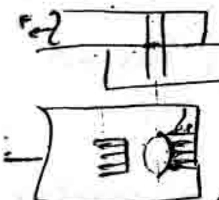
③ $d = \sqrt{5s} - 0{,}2$



$p_2 \Rightarrow p_1$ (enakomerna porazdelitev na projekcijo ploskve)

bočni tlak

$$② \quad \sigma_e = p = \frac{\Phi}{n\cdot d(\sum s)_{min}} < \sigma_{edop}\left(\begin{array}{c}\text{osnovni material} \\ \text{material kovice}\end{array}\right)$$

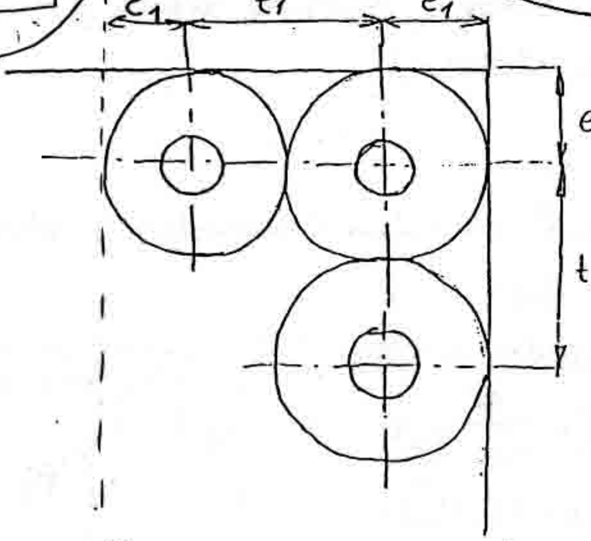


$\sigma_e = p < p_{mejni} = \sigma_{e\,dop}$

$p_{mejni} = f$ (osn. mat., mat. kovice)

$p_{dop} = f$ (slabšega materiala v spoju)

II ①



$t_1 \doteq (1{,}5 \text{ do } 2)\cdot d$

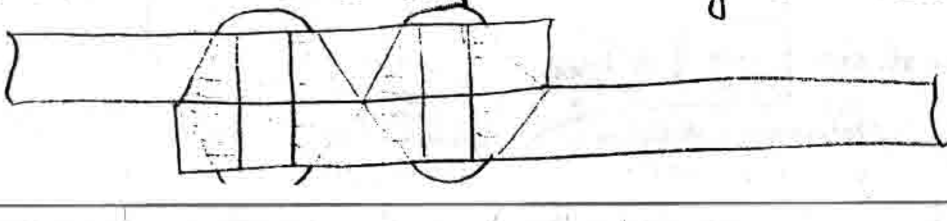
$e_1 = (1 \text{ do } 1{,}5)\cdot d$

$e_1 > e_2$

$t_2 < t_1$

BOLJŠE je če se sledi napetosti rahlo prekrivajo.

V smeri sile lahko razporedimo največ 5 kovic.



Prednosti kovičnih spojev:
- spajamo lahko različne materiale v celoto
- osnovni mat. se ne segreje veliko
- pločevine ni potrebno predhodno obdelat.

material	→	kovice
kovinske jeklene	→	jeklene
betrne	→	betrene, l
aluminijaste	→	aluminijaste

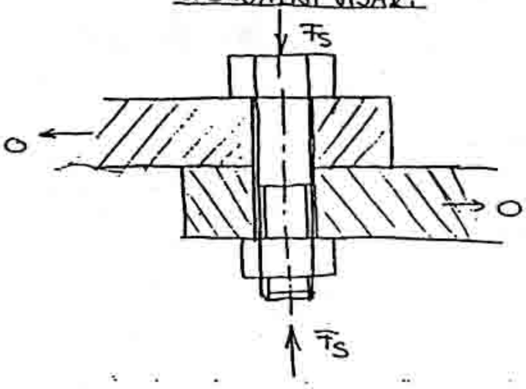
Slabosti kovičnih spojev:
- nevarnost rjavenja
- nastajanje galvanskih tokov (elektroliza) → razkrajanje materiala
- z luknjo v osnovnem mat. ji osnovni mat. oslabljen.
- drag postopek → ravnanje valjčnih površin
→ načrt

ELEMENTI ZA RAZSTAVLJIVE ZVEZE

VIJAKI

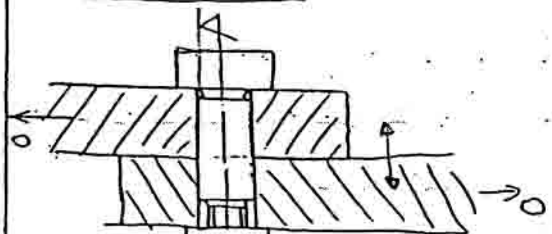
Delitev:
1.) Spenjalni vijak
2.) prilagodni vijak
3.) gibalni vijak

SPENJALNI VIJAK:



Spenjalno silo služi za prevzem zunanje obremenitve. Obremenitev je samo natezna

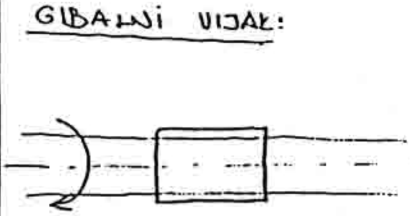
PRILAGODNI VIJAK:



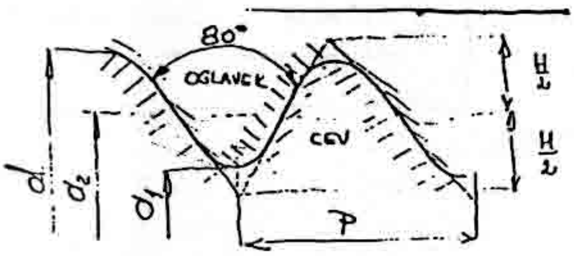
čep h6
luknja K7

Telo vijaka vstavimo v luknjo. Luknja izdelana na toleranco. Obremenitev prevzame s strigom in bočnim ka... S svojo obliko prepreči zunanjo obremenit...
Nosi z dejanskim strigom

GIBALNI VIJAK:

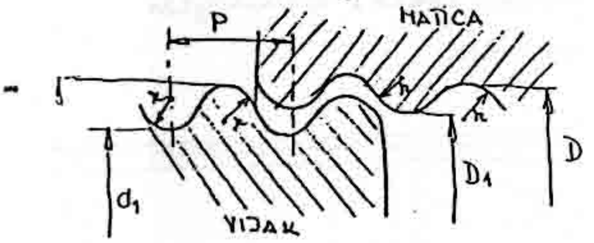


Omogoča spremembo translacija⇔rotacija



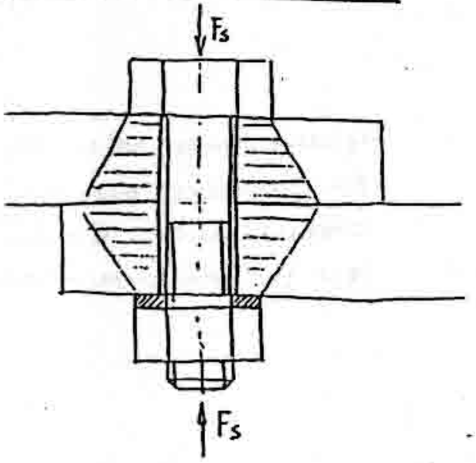
[Rc]

:) EDISONOV NAVOJ :



[E]

. SPENJALNI VIJAK:

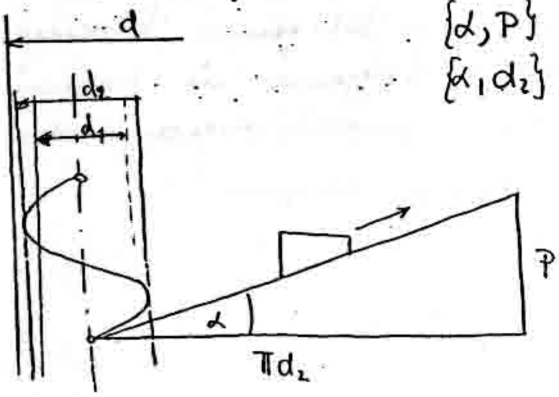


* str. 39.

Navoj je vijačnica podana z $\{P, d_2\}$

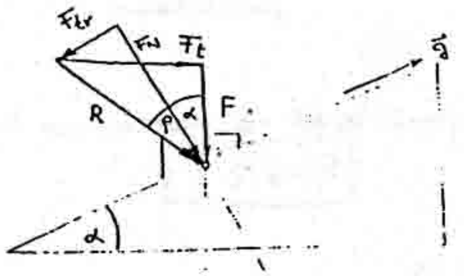
$\{\alpha, P\}$

$\{\alpha, d_2\}$



$$tg\alpha = \frac{P}{\pi d_2}$$

a) gibanje navzgor:

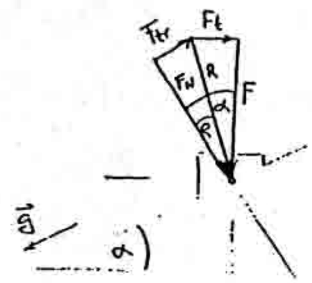


$F_t = F \cdot tg(\alpha + \rho)$

$tg\,\rho = \dfrac{F_N \cdot \mu}{F_N}$

$tg\,\rho = \mu_{\frac{m}{g}}$

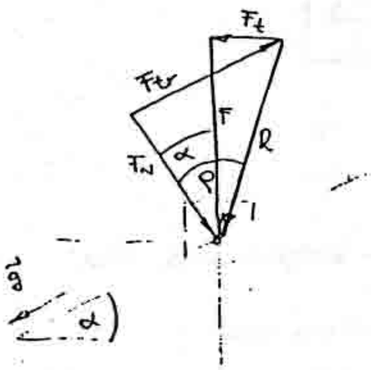
b) gibanje navzdol:



$F_t = F \cdot tg(\alpha - \rho)$

$\alpha > \rho$ breme zadržujemo na strmini
nesamozapornost

$\alpha = \rho$ meja samozapornosti



$F_t = F \cdot tg(\rho - \alpha)$

$\rho > \alpha$ samozapornost

*

$F_s \geq \dfrac{Q}{\mu \frac{m}{g}}$

$F_s = \dfrac{Q}{\mu \frac{m}{g}} \cdot S$ S – varnost (odmik od mejne vrednosti)

$S = 2 \div 3$

$\dfrac{F_s}{n} = F$

F – sila na en vijak

$n > 2$

n v smeri sile < 5

m/p – matica/podložka

$M_{KLJ} = M_{m/p} + M_{vij}$

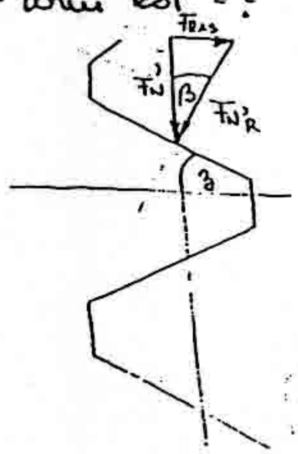
$M_{KLJ} = F \cdot \mu \cdot \dfrac{d_A}{2} + F_t \cdot \dfrac{d_2}{2}$

$F_t = F \cdot tg(\alpha + \rho)$

$M_{KLJ} = F \cdot \mu_A \cdot \frac{d_A}{2} + F \cdot tg(\alpha+\rho) \cdot \frac{d_2}{2}$

$\frac{d_A}{2}$ - polmer na katerem se matica naslanja na podložko

ρ - torni kot = ?



nagnjeni boki → povečano trenje

$\boxed{\rho \to \rho'}$?

$F_t = F_{N'R} \cdot \mu$

$F_t = \frac{F_{N'}}{\cos\beta} \cdot \mu$

$tg\,\rho' = \frac{\mu}{\cos\beta} = \mu'$

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

$tg\,\rho' = \mu'$

$M_{KLJ} = M_{N/P} + M_{N}$

$M_{NP} = F_{\text{jen}} \cdot \frac{d_A}{2} + F_t \cdot \frac{d_2}{2}$

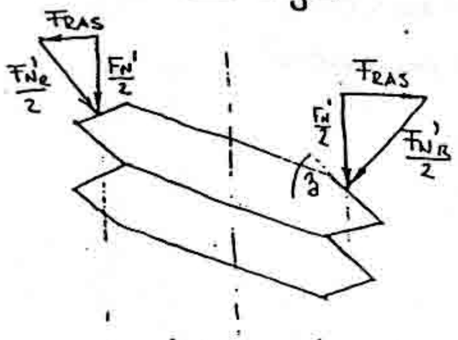
$F_t = F \cdot tg(\alpha+\rho)$

$M_{KLJ} =$

$\rho \to \rho'$

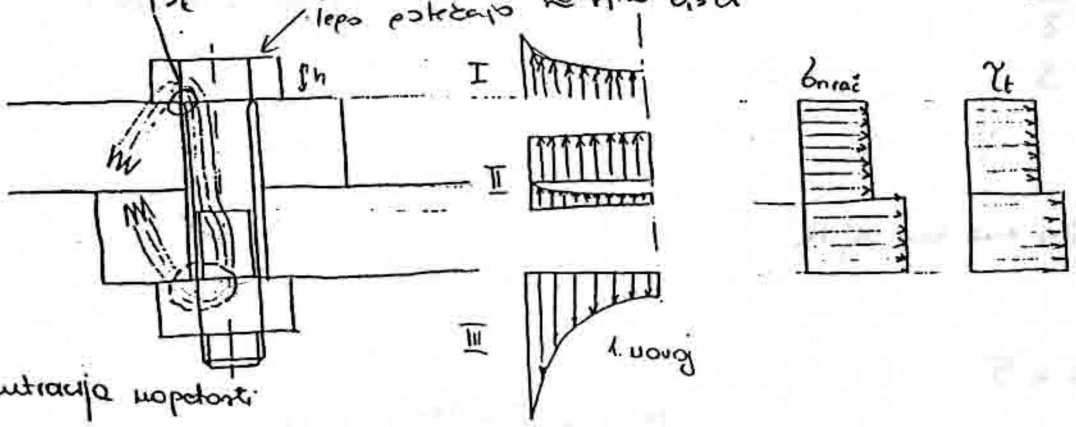
$$\boxed{M_{KLJ} = F \cdot \mu_A \cdot \frac{d_A}{2} + F \cdot tg(\alpha+\rho') \cdot \frac{d_2}{2}}$$

<u>Obremenitev navoja:</u>



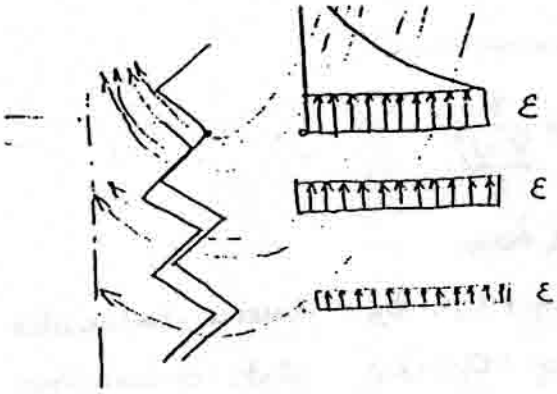
F_{RAS} - raspiralna sila

Raspiralna sila:
- centrira matico na steblo
- lahko povzroči porušitev matice



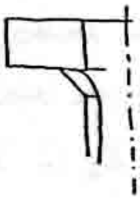
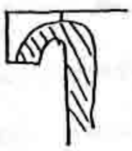
koncentracija napetosti

Raziskave so pokazale, da bo vijak pri dinamični obremenitvi odletel pri:
$\mathrm{I} \to 10\%$
$\mathrm{II} \to 20\%$
$\mathrm{III} \to 70\%$

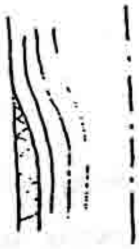
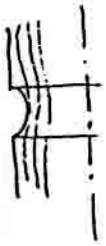


Prvi navoj je najbolj obremenjen. Največji premik preprečuje. Večina natezuih sil gre preko prvega navoja. Največja koncentracija napetosti ob prvem navoju.

zmanjševanje vpliva zareznega učinka:

I)  ali 

10% povišitve

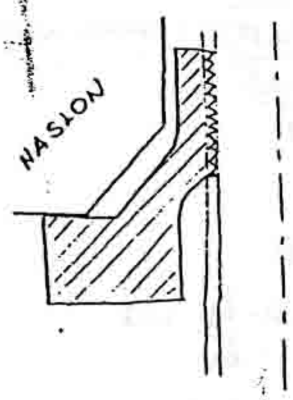
II)  ali 

20% povišitve

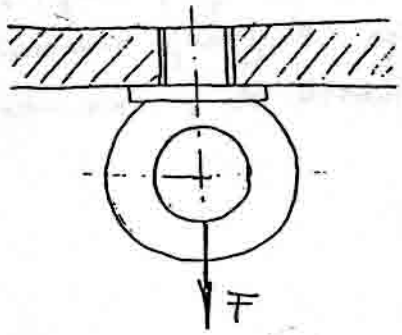
primeri razbremenjevanja prvega navoja:

III. 

30% povišitve



OČESNI VIJAK:



$$\sigma = \frac{F}{\frac{\pi \cdot d_1^2}{4}}$$

$\sigma \leq \sigma_{dop}$

$\sigma_{dop} = 0{,}6 \cdot \sigma_D$ dinam. obremenitev

$\sigma_{dop} = 0{,}6 \cdot \sigma_\nu$ stat. obremenitev

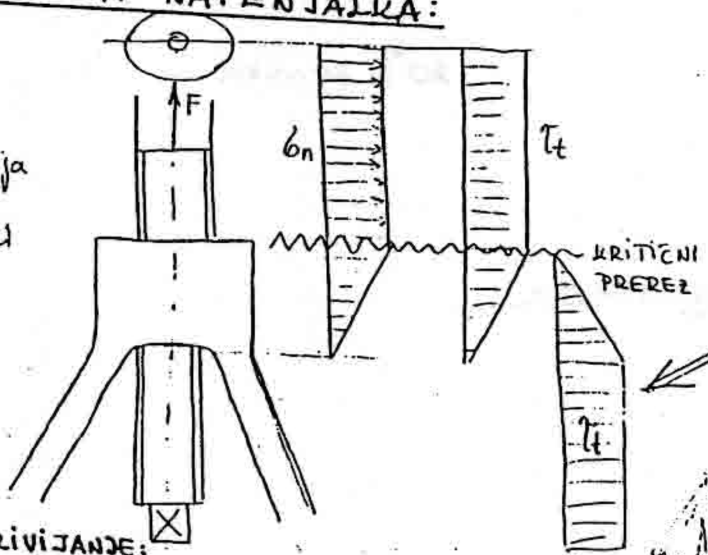
* 0,6 so združeni faktorji b_2, β_k, S

b_2 - hrapavost površine v korenu navoja

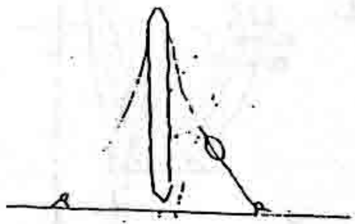
β - makrozarezni učinek v prvem navoju

b_1 - upoštevamo tako da sta σ_D in σ_ν funkciji premera.

VIJAČNA NAPENJALKA:



Torzijske napetosti v kritičnem prerezu se izničijo ko zadržimo vijak in privijamo matico



PRIVIJANJE:

$F\,[0 \rightarrow F_{max}]$

$\sigma, \tau\,[0 \rightarrow \sigma_{max}, \tau_{max}]$

$$\sigma = \frac{F}{\frac{\pi d_1^2}{4}}$$

$$\tau_t = \frac{M_t}{W_{p1}} \quad ; W_p \text{ (na } d_1)$$

$$M_t = F \cdot tg(\alpha + \rho') \cdot \frac{d_2}{2}$$

$$\sigma_p = \sqrt{\sigma_m^2 + 3\tau_t^2}$$

$\sigma_p \leq \sigma_{dop}$

$\sigma_{dop} = 0{,}6 \cdot \sigma_\nu$

OBRATOVANJE:

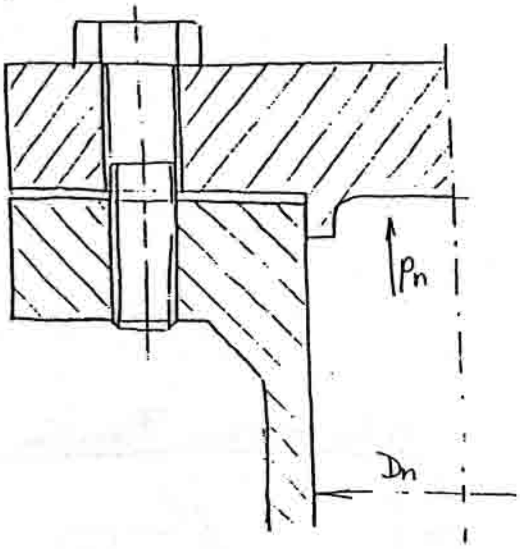
$$\sigma = \frac{F + \Delta F}{\frac{\pi \cdot d_1^2}{4}}$$ $\Delta F \rightarrow$ sunek vetra

$\tau_t = \varnothing$

$\sigma \leq \sigma_{dop}$

$\sigma_{dop} = 0{,}6 \cdot \sigma_D$ ali σ_ν

a) Vijak pritegnjen z neposnano silo prednapetja malo obremenjen



M_{KLJ} - neposnan
F - -"-
σ - -"-
τ_t - -"-

p_n povzroči $F_{odpiranja}$ pokrova

$$F_{OD} = \frac{\pi \cdot D_n^2}{4} \cdot p_n$$

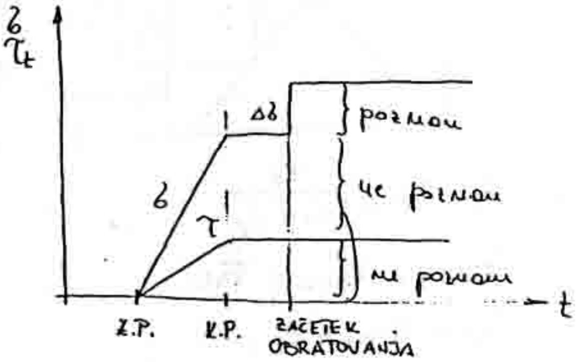
$$F_1 = \frac{F_{OD}}{n}$$

n - število vijakov na obodu

$$\Delta\sigma = \frac{F_1}{\frac{\pi d_1^2}{4}}$$

$$\Delta\sigma \leq \sigma_{dop}$$

$$\sigma_{dop} = \frac{0{,}6 \cdot \sigma_{0,D} \cdot 0{,}75}{S}$$

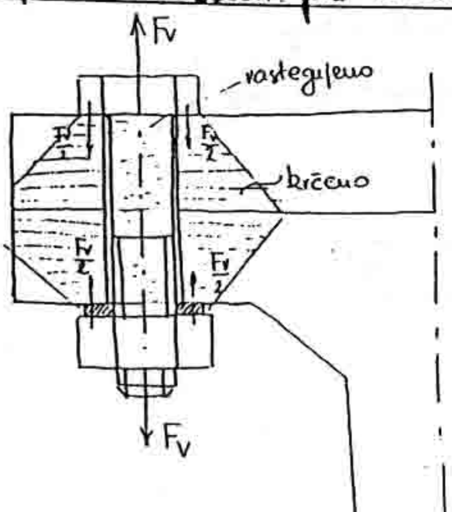


Z.P. - začetek privijanja
K.P. - konec privijanja

$S = 1{,}5 \div 3$ (upošteva nek σ)
$0{,}75$ (upošteva nek τ)

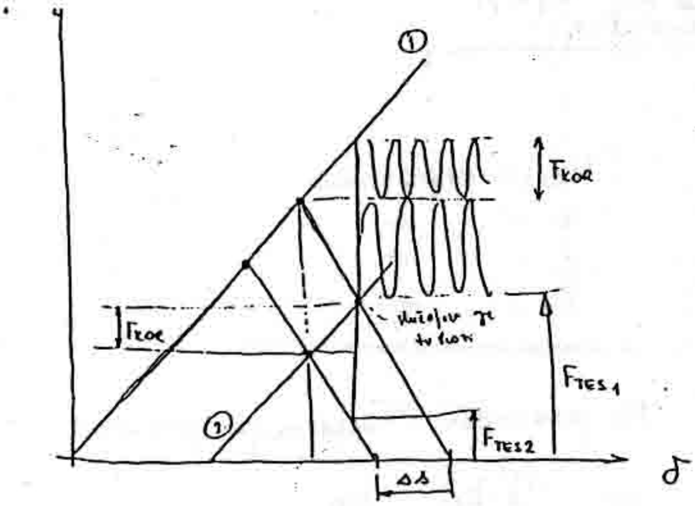
Sam sistem dimenzioniranja je slab. Ocena ali zdrži ali ne je zelo groba.

b) Vijaki zatezani pri znani sili in obremenjeni s konstantno silo



$$M_{KLJ} = F_v \cdot tg(\alpha + \rho') \cdot \frac{d_2}{2} + F_v \cdot \mu_1 \cdot \frac{d_A}{2}$$

$F_v \rightarrow \sigma$
$M_t \rightarrow \tau_t$



Dimenzioniranje:

$$F_v \rightarrow \begin{cases} \sigma_v = \dfrac{F_v}{\frac{\pi \cdot d_1^2}{4}} \\ \tau_t = \dfrac{F_v \cdot tg(\alpha+\rho') \cdot \frac{d_2}{2}}{W_t} \end{cases}$$

$$\rightarrow F_{v\,max} \rightarrow \begin{cases} \sigma_{max} = \dfrac{F_{max}}{\frac{\pi \cdot d_1^2}{4}} \\ \tau_t = \dfrac{tg(\alpha+\rho') \cdot \frac{d_2}{2} \cdot F_v}{W_1} \end{cases}$$

$$\sigma_p = \sqrt{\sigma_{max}^2 + 3 \cdot \tau_v^2}$$

$$\sigma_p \leq \sigma_{dop}$$

$$\sigma_{dop} = 0{,}8 \cdot \sigma_v$$

č poznam M_{klj} in F_{kor}

$$M_{klj} = F_v \cdot tg(\alpha+\rho') \cdot \frac{d_2}{2}$$

$$\Downarrow$$

$$F_v = \frac{M_{klj}}{tg(\alpha+\rho') \cdot \frac{d_2}{2}}$$

$$F_v = f(M_{klj})$$

$$F_v \begin{cases} \nearrow \sigma_v \\ \searrow \tau_{tv} \end{cases}$$

$$F_1 = F_{kor} \cdot \frac{c_v}{c_v + c_p}$$

$$F_{max} = F_v + F_1$$

$$\sigma_{max} = \frac{F_{max}}{\frac{\pi \cdot d_1^2}{4}}$$

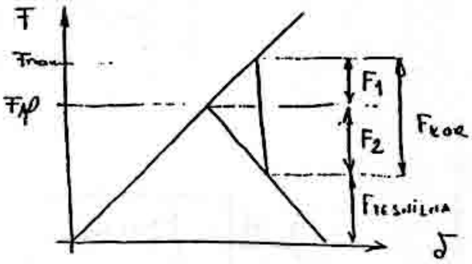
$$M_{klj}$$

$$\sigma_p = \sqrt{\sigma_{max}^2 + 3\,\tau_t^2}$$

$$\sigma_p \leq \sigma_{dop}$$

$$\sigma_{dop} = 0{,}8 \cdot \sigma_v$$

a) č poznam $F_{tesnilna}$ in F_{kor}



$$F_{kor} = F_1 + F_2$$

$$F_1 = F_{kor} \cdot \frac{c}{c_v}$$

$$F_2 = F_{kor} \cdot \frac{c}{c_v}$$

$$F_1 = F_{kor} \cdot \frac{c_v}{c_v + c_p}$$

$$F_{max} = F_{kor} + F_{TES}$$

$$F_v = F_{max} - F_1$$

$$M_{klj} = F_v \cdot tg(\alpha+\rho') \cdot \frac{d_2}{2}$$

$$\tau_t = \frac{M_{klj}}{W_1}$$

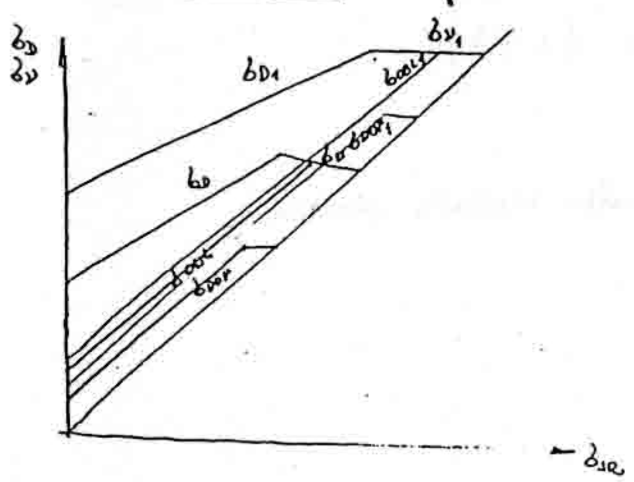
$$\sigma_v = \frac{F_v}{\frac{\pi \cdot d_1^2}{4}} \Rightarrow \sigma_{max} = \frac{F_{max}}{\frac{\pi \cdot d_1^2}{4}}$$

$$\sigma_p = \sqrt{\sigma_{max}^2 + 3 \cdot \tau_v^2}$$

$$\sigma_p \leq \sigma_{dop}$$

$$\sigma_{dop} = 0{,}8 \cdot \sigma_v$$

... za vijake



Tudi če izboljšam material za vijak se mi karakteristiki σ_{OBL1} in σ_{DOP1} le malo povečati. Zato za vijak ni smiselno uporabljati ne vem kako dobre materiale

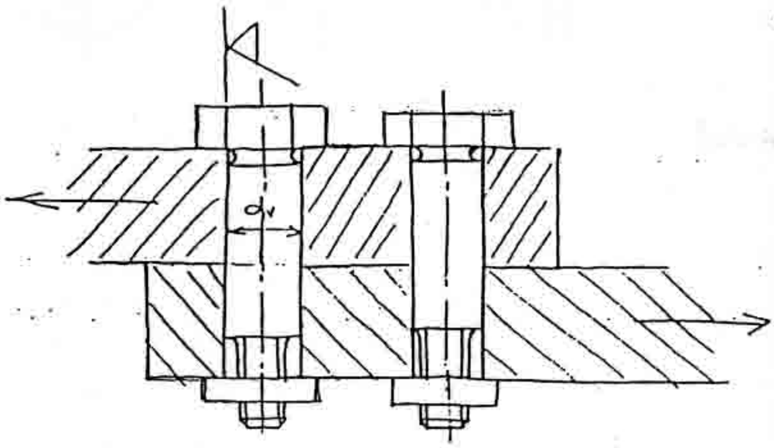
Smithov diagram je zelo ozek, preverim če mi amplitudna napetost prevelika

$$\sigma_a = \frac{F_a}{\frac{\pi \cdot d_1^2}{4}}$$

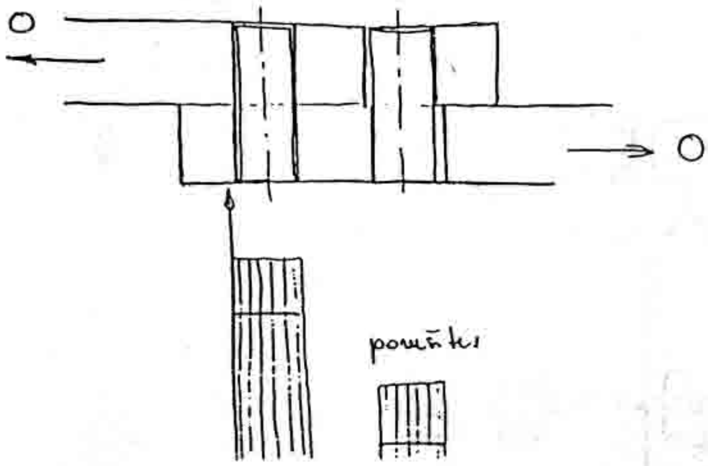
$$\sigma_a \le \sigma_{adop}$$

$$\sigma_{a\,dop} = 30 \div 70 \ \frac{N}{mm^2}$$

IV. PRILAGODNI VIJAK



Vstavljen na toleranco pomembna točnost izdelave lukenj.



če luknja ni točno izdelana.

V vrsti naj ne bo veliko vijakov $(2 \div 4)$

DIMENZIONIRANJE:

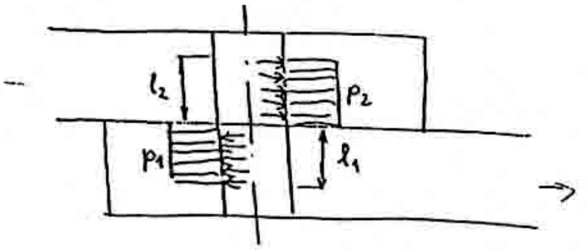
$$\tau_s = \frac{Q}{\frac{3}{4} \cdot z \cdot m \cdot \pi \cdot \frac{d_v^2}{4}}$$

m – število strižnih ploskev

$\tau_s \leq \tau_{s\,dop}$

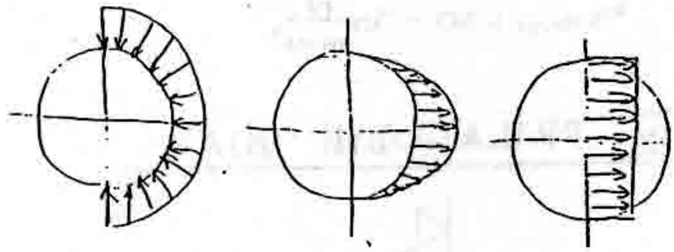
$\tau_{s\,dop} = f(\text{mat. vijaka})$

Kontaktni tlak:



$p_1, p_2 = f(l_1, l_2)$

$$p = \frac{Q}{\frac{3}{4} z \cdot d_v (\Sigma l)_{min}}$$



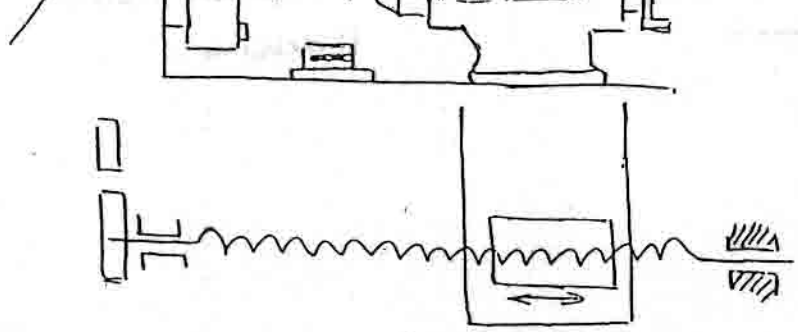
$p \leq p_{dop}$

$p_{dop} = f(\text{mehkejšega materiala})$

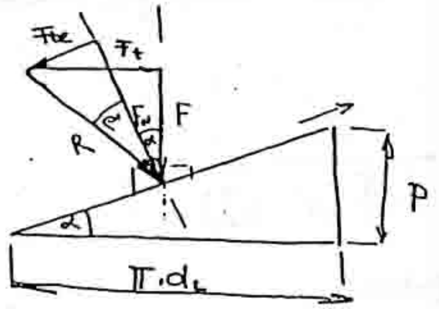
V. GIBALNI VIJAK:

gibanje $R \to T$ ali gibanje $T \to R$

shema gib. vijaka na str.



… v translacijo



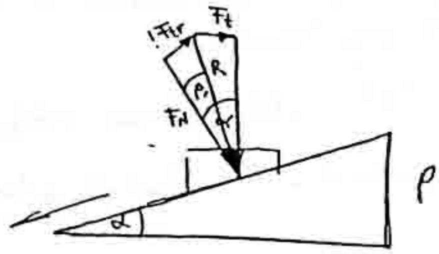
izkoristek

$$\eta_{R-T} = \frac{A_{od}}{A_{do}} = \frac{F \cdot P}{F_t \cdot \pi \cdot d_2}$$

$$\eta_{R-T} = \frac{\cancel{F} \cdot tg\,\alpha \cdot \cancel{\pi d_2}}{\cancel{F} \cdot tg(\alpha+\rho') \cdot \cancel{\pi d_2}}$$

$$\eta_{R-T} = \frac{tg\,\alpha}{tg(\alpha+\rho')}$$

2.) Translacija v rotacijo



$\rho' < \alpha$ $\quad \pi d_2$

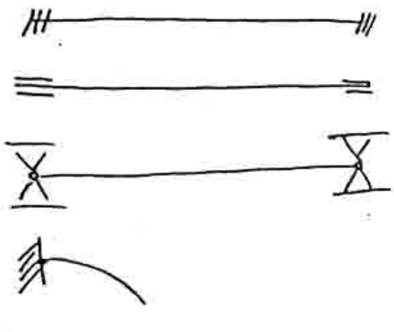
$$\eta_{R-T} = \frac{A_{do}}{A_{od}} = \frac{F_t \cdot \pi \cdot d_2}{F \cdot P}$$

$$\eta_{R-T} = \frac{tg(\alpha-\rho')}{tg\,\alpha}$$

Izkoristek lahko izboljšamo:

1. ρ-μ manjša, gladka površina, mazanje
2. α velik
3. pravokotni navoj 

Vijak je dolg zato nastopi problem uklona. Sila se vnaša na mestu matica
Razčistiti je treba kakšno je podporje



$l_{uklona} = ?$

$$F_k = \pi^2 \cdot \frac{E \cdot I_{min}}{l_0^2}$$

$$\sigma_k = \frac{F_k}{S} = \pi^2 \cdot \frac{E \cdot I_{min}}{l_0^2 \cdot S} = \pi^2 \cdot \frac{E}{\lambda^2}$$

$$\lambda = \frac{l_0}{i}$$

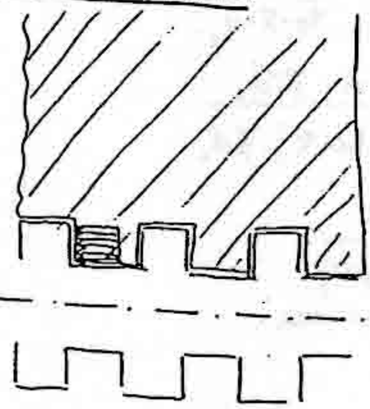
$$i = \sqrt{\frac{I_{min}}{S}}$$

če $\lambda > 105 \Rightarrow$ EULER

če $\lambda < 105 \Rightarrow$ TETMAJER

... je zato zamenoljiva, zato pa nastopi problem na bokih in to KONTAKTNI TLAK

KONTAKTNI TLAK:



$$p = \frac{F}{i \cdot \frac{\pi}{4}(d^2 - D_1^2)}$$

$p \leq p_{dop}$

$p_{dop} = f$(mehkejšega materiala, hitrosti mazanje, nemazanje)

Uporabljati par materialov z najmanjšimi koeficienti trenja.

$\mu = 0{,}1 \div 0{,}15$ drsno trenje

$\mu = 0{,}0015$ kotalno trenje

Nosi $5 \div 8$ navojev

dolžina matice $l \leq 8 \cdot P$

obvezno mazanje

Za konstrukcijo moramo predpisati dva pogoja:

- utekanje
- obratovanje

utekanje:

$p \leq p_{dop}$ (mehk. mat, v_t, intenzivnost mazanja)

$F_{utekanja} = p_{dop} \cdot (6 \div 8)\, \frac{\pi}{4} \cdot (d^2 - D_1^2)$

obratovanje:

$$p = \frac{F_{obrat}}{i \cdot \frac{\pi}{4} \cdot (d_2 - D_1^2)}$$

$p \leq p_{dop}$

...anje naredimo na dva načina:

- v tovarni izvedejo utekanje
- režim utekanja ne predvidi

...ko izveden (2):

manjši število navojev

poboljšat kvaliteto izdelave

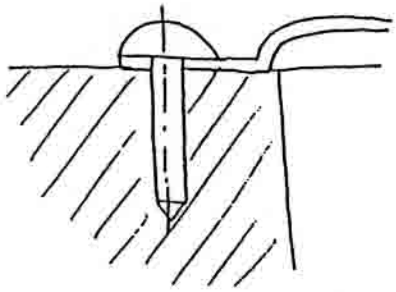
intenzivno mazanje (površino dvignit od površine z mazivom)

ZATIČI IN SORNIKI

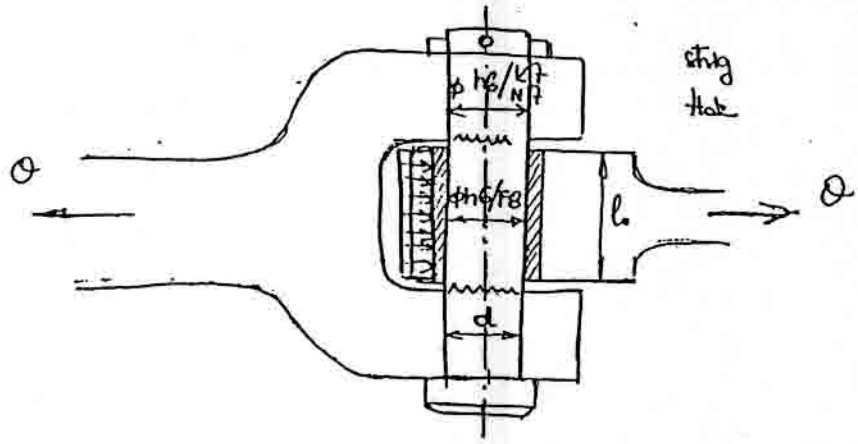
ZATIČI: so zmeraj za nepremične zveze. Zveza ni obnovljiva
SORNIKI: tudi za premične zveze, zveza je obnovljiva

Zatič mora biti za 2 razreda trši material od osnovnega materiala

ZATIČ:



SORNIK:



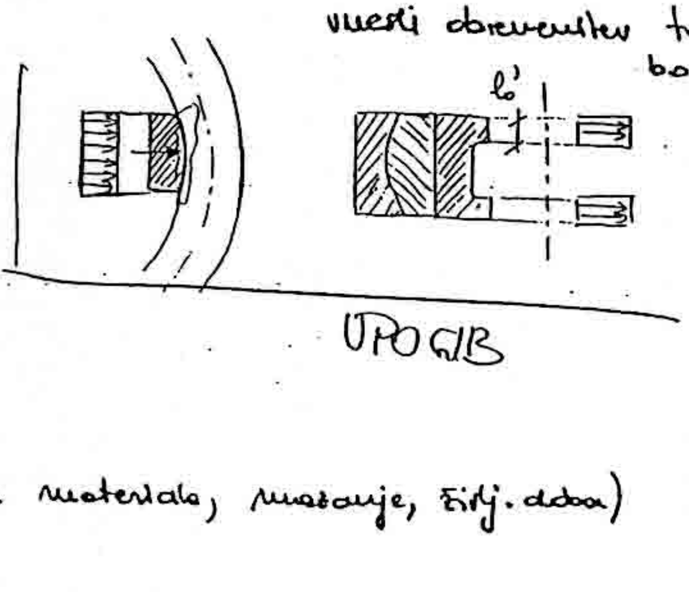
Standardne oblike zatičev in sornikov:

Obremenitve, ki nastopajo:

ORNIK

BOČNI TLAK
UPOGIB
STRIG.

vnesti obremenitev tako da ne bo lokalne obrabe



UPOGIB

Bočni tlak

$$p = \frac{Q}{2 \cdot d \cdot l_0'}$$

$p \leq p_{dop}$

$p_{dop} = f$ (mehkejšega materiala, mazanje, življ. doba)

Upogib

toge vilice

b) manj toge

$$p = \frac{Q}{d \cdot l_0}$$

$$\sigma_{up} = \frac{M_{up}}{W}$$

$$\sigma_{up} < \sigma_{dop}$$

3. STRIG:

$$\tau = \frac{Q}{\frac{\pi d^2}{4} \cdot m}$$ m – št. str. ploskev.

$\tau \le \tau_{dop}$ (materiala sornika)

mat. za sornik: Č.0360 – Č.0460
jeklo za poboljšanje Č.1530

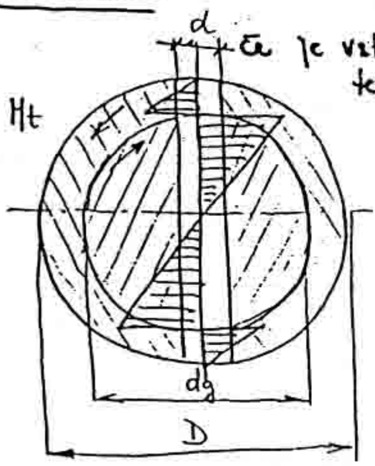
ZATIČ

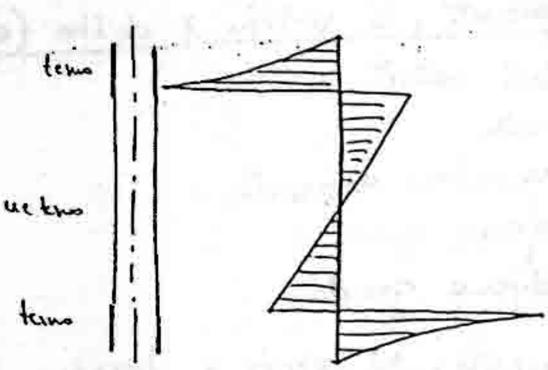
Je varovalo pred velikimi momentom

DIMENZIONIRAMO:

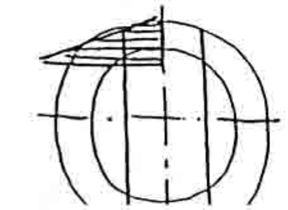
a) da zdrži
b) kot varnostni element.

PREČNI ZATIČ:

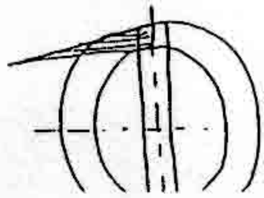




debel zatič



tanek zatič



$\tau =$

$\tau \leq \tau_{dop}$

$$\tau_{Dop} = \frac{\tau_D \cdot b_1 \cdot b_2}{\beta_{kt} \cdot S}$$

kot varnostni element

pri $M_{t\,VAROVANJA}$ moj spoj popusti

$$\tau = \frac{M_{tv}}{\frac{\pi d_t^2}{4} \cdot d}$$

(?)

$\tau = \tau_m$

⇓ Izračunam

$d = ?$

$$\tau = \frac{\cancel{4} M_t}{\frac{\pi \cdot d_t^2}{4} \cdot d_g}$$

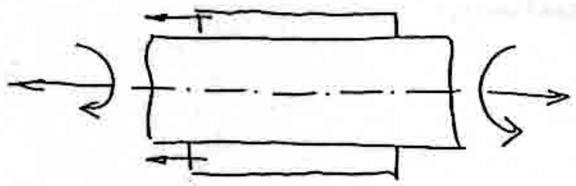
$$\tau = \frac{M_t}{\frac{\pi \cdot d_t^2}{4} \cdot d_g}$$

$$d_t = \sqrt{\frac{4 M_t}{\pi\, d_g\, \tau}}$$

$\tau = \tau_m$!

GREDNE VEZI

prenos vrtilnega momenta in sil med gredjo in pestom



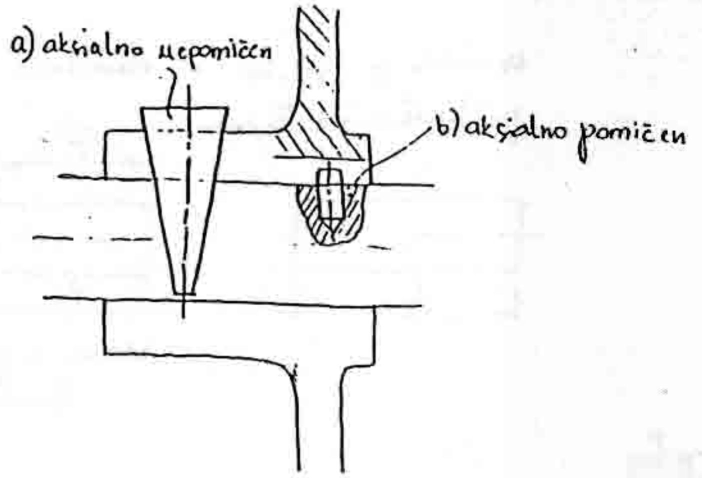
gredne vezi so nepomične ali pa aksialno pomične

Elementi, ki vežejo z obliko (OBLIKOVNE GREDNE VEZI)

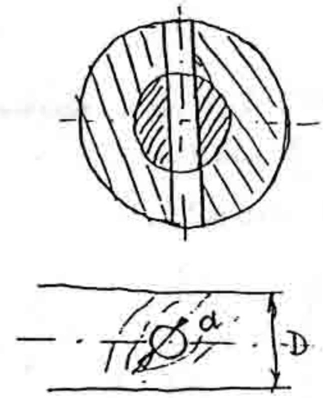
- prečni zatič
- moznik
- segmentni moznik
- utorjene gredi
- ozobljene gredi

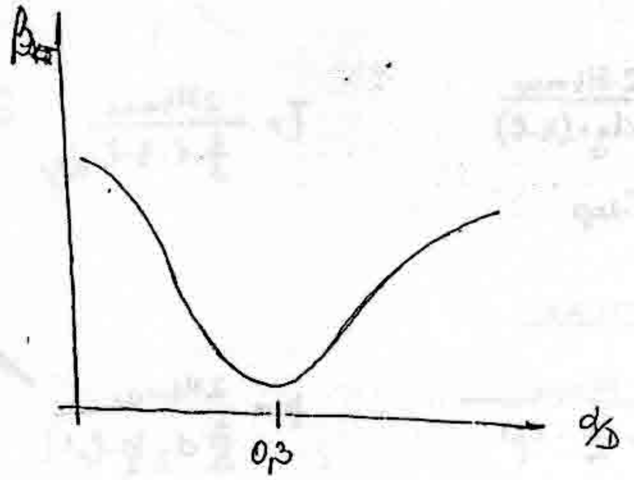
Elementi, ki vežejo s trenjem (TORNE GREDNE VEZI)

- zagozda
- spajalni stik
- stožčasti nased



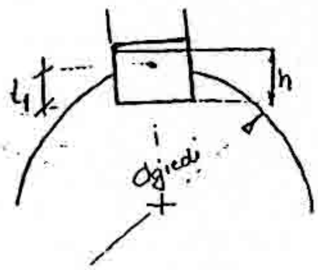
Pomembno pri preračunu zatiču je razmerje med premerom zatiča in premerom gredi (d/D). Zarezni učinek.



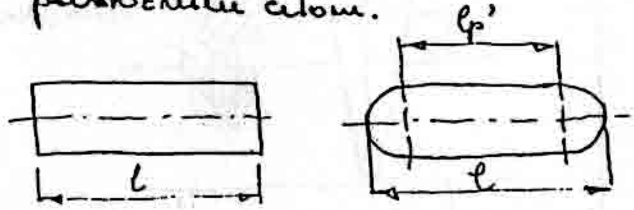


MOZNIK:

Standardne dolžine moznikov:

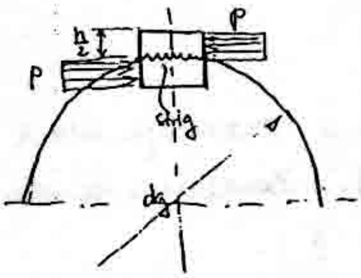


moznik je lahko z ravnim ali polkrožnim čelom.



izdelan s prstnim frezalom

napetosti v mozniku:
strig
bočni tlak



STRIG:

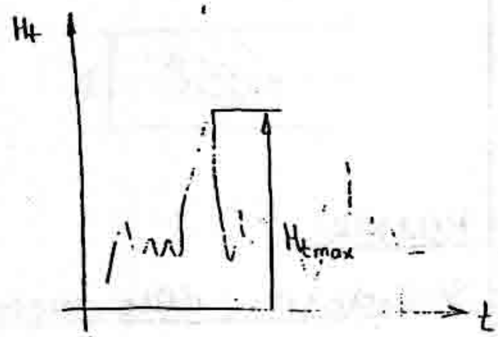
$$\tau = \frac{2 \cdot M_{t\,max}}{d_g \cdot (b \cdot l)} \qquad \tau = \frac{2 M_{t\,max}}{\frac{2}{3} \cdot i \cdot b \cdot l \cdot d_g}$$

če imamo več kot dva moznika nosi le $\frac{2}{3}$ moznikov
i – število moznikov.

$$\tau \le \tau_{dop}$$

BOČNI TLAK:

$$p = \frac{2 \cdot M_{t\,max}}{d_g \cdot \frac{h}{2} \cdot l_p'} \qquad p = \frac{2 M_{t\,max}}{\frac{2}{3} d_g \cdot \frac{h}{2} \cdot l_p' \cdot i}$$



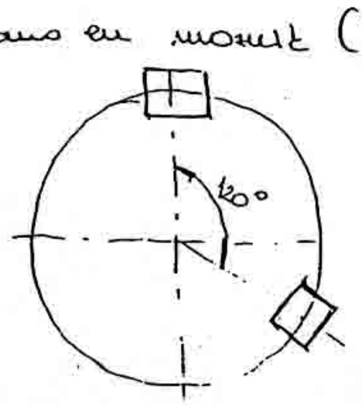
$$p \le p_{dop}$$

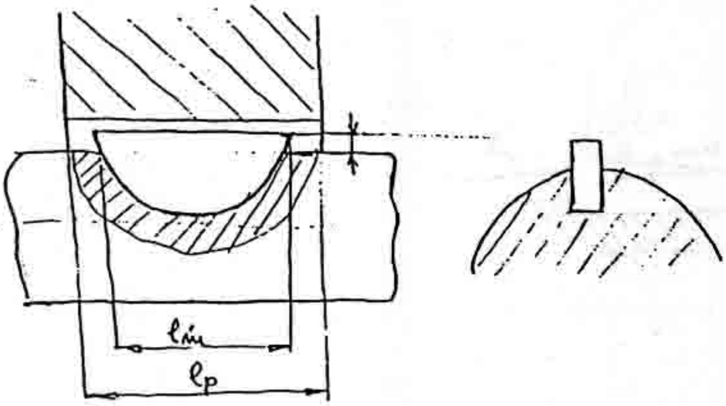
$p_{dop} = f$ (mehkejšega materiala v zvezi)

p_{dop} – mat. pesta, mat. moznika, mat. gredi

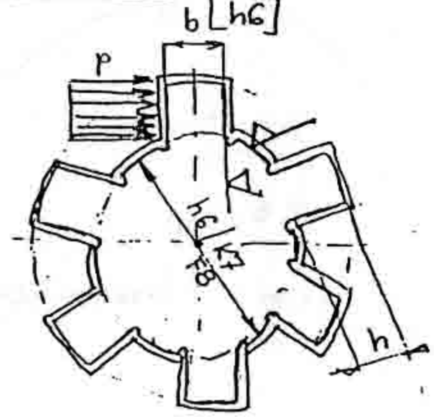
Moznik za en razred trši mat. kot gred: Č.0460, Č.1530

Časih pa ni dovolj samo en moznik (če imamo ohlapen prileg)





UTORJENE GREDI :



Obremenitev je bočni tlak:

$$p = \frac{2 M_{t max}}{d_{sr} \cdot \frac{2}{3} \cdot i \cdot h \cdot l_p}$$

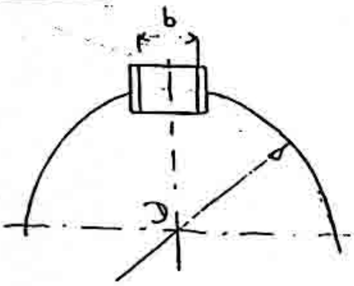
$p \leq p_{dop}$

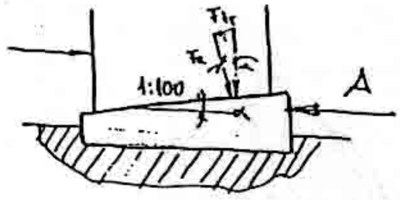
p_{dop} = f (menkejšga materiala) – nepremična zveza
f (menk. materiala + obraba) – pomična zveza

Standardne dolžine utorjene gredi:

.UKNE GREDNE VEZI

AGOZDA:





Algoritem preračuna:

$F_{tr} = \mu_{\frac{m}{g}} \cdot F_R$

$M_{tmax} = D \cdot F_{tr}$

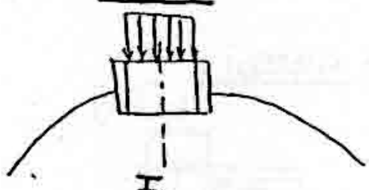
$F_R = \dfrac{F_{tr}}{\mu_{\frac{m}{g}}}$

$A_1 = F_R \cdot tg(\alpha + \rho)$

$A_2 = F_R \cdot tg\,\rho$

$A = A_1 + A_2 = F_R \cdot [tg(\alpha+\rho) + tg\rho]$

TLAK:

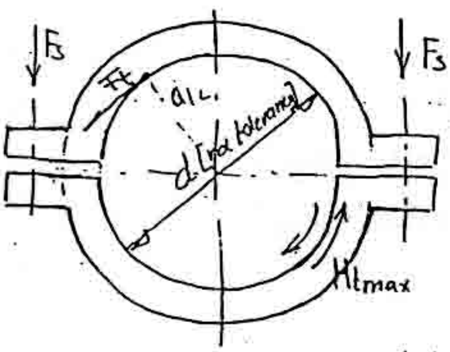


$p = \dfrac{F_R}{b \cdot l_n}$

$p \leq p_{dop}$

$p_{dop} = f$ (mehkejšega materiala)

ENJALNI STIK:



$F_t = \dfrac{2 \cdot M_{tmax}}{d}$

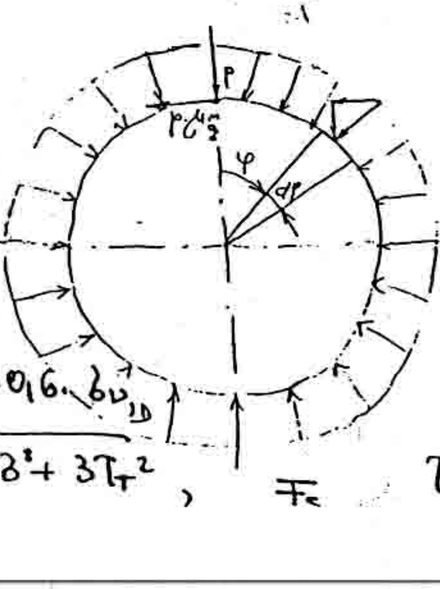
$F_t < F_{trenja}$

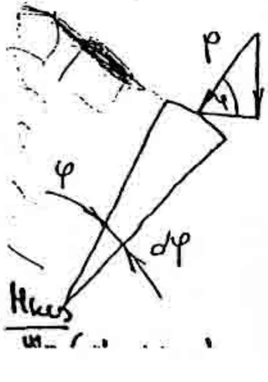
$F_t \cdot S = F_{trenja}$

S - varnost $\quad S = 1{,}5 \div 2$

$F_t = \int_0^{2\pi} p \cdot \mu_{\frac{m}{g}} \cdot \frac{d}{2} \cdot l_p \cdot d\varphi$

$F_t = \pi \cdot p \cdot d \cdot l_p \cdot \mu_{\frac{m}{g}}$





$F_S = \int_0^{\pi} p \cdot \sin\varphi \cdot \frac{d}{2} \cdot l_p \, d\varphi$

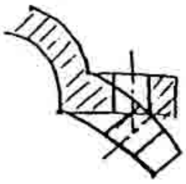
$F_S = p \cdot d \cdot l_p$

$\cancel{F_S} = \dfrac{F_E}{\mu}$

$\sigma_{dop} = 0{,}6 \cdot \sigma_{D}$

$\sigma = \sqrt{\sigma^2 + 3\tau_T^2}$, $\quad F_E \quad \tau = \frac{M_{tmax}}{W_p}$ $\quad M_{...} = F_{...}(\alpha + \rho) \cdot \frac{d_2}{2} + F ... \frac{d}{...}$

deformacija:



Vijak bo treba preverjati pri končni obremenitvi in ga pravilno dimenzionirat.

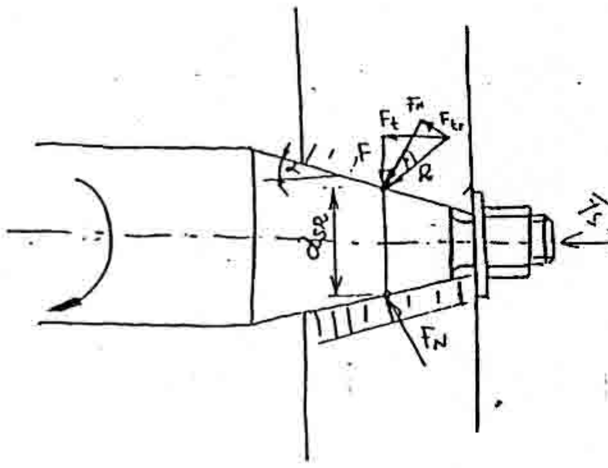
$$\sigma = \frac{F_{s1}}{\frac{\pi \cdot d_1^2}{4}}$$

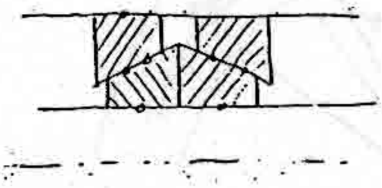
$$\tau = \frac{M_t}{W_1} = \frac{F_s \cdot tg(\alpha+\rho) \cdot \frac{d_0}{2}}{W_1}$$

$$\sigma_p = \sqrt{\sigma^2 + 3\tau_t^2}$$

$$\sigma_p \leq \sigma_{dop}$$

STOŽČASTI NASED:



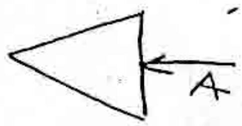


če bo α majhen bo zveza samozaporna

$F_N \cdot \mu_g^m = F_{tr}$ ✓

S - varnost

$F_{tr} \cdot d_{sr} = S \cdot M_{t\,max}$



$$F_N = \frac{S \cdot M_{t\,max}}{d_{sr} \cdot \mu_g^m}$$

M_{us}, σ, τ

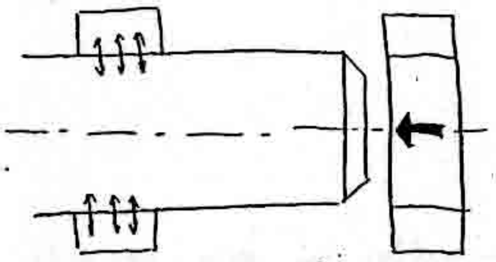
$$\frac{2 S M_{t\,max} \sin(\alpha+\rho)}{d_{sr}\,\mu \cos\rho}$$

$$R = \frac{F_N}{\cos\rho}$$

$A = 2 \cdot A_1 = 2 \cdot R \cdot \sin(\alpha+\rho)$ ✓

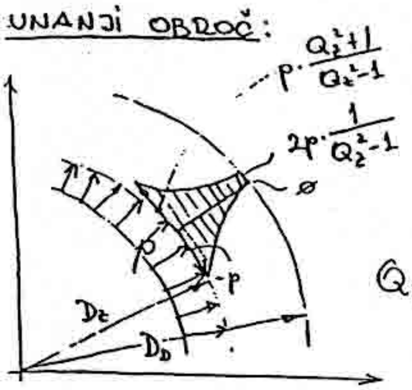
$$A = \frac{2 F_N \sin(\alpha+\rho)}{\cos\rho}$$

ESEN ALI KRČNI NASED:



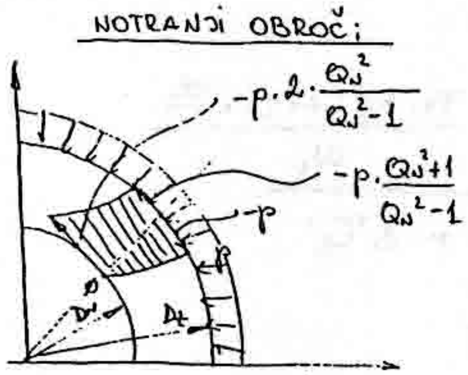
petostuo stanje:

UNANJI OBROČ:

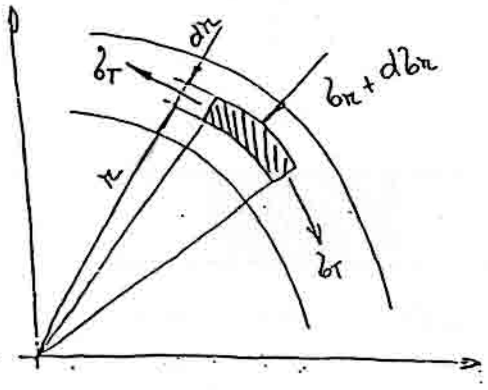


$$Q_Z = \frac{D_Z}{D_T}$$

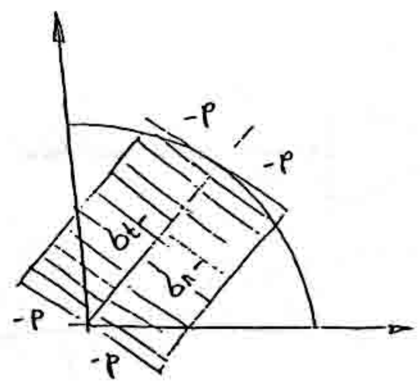
NOTRANJI OBROČ:



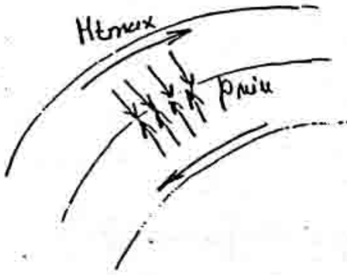
$$Q_N = \frac{D_I}{D_u}$$



je notranji obroč poln:



... na mejni ploskvi:



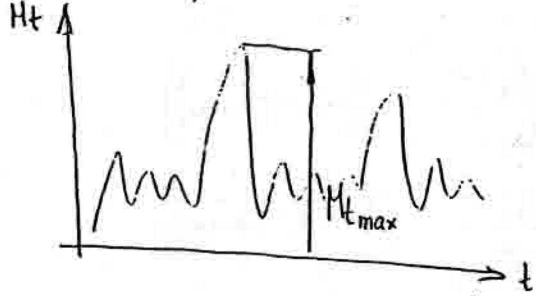
$$p_{min} \cdot \mu_{mg} \cdot \pi \cdot d_T \cdot l \geq \frac{2 \cdot M_{tmax}}{d_T}$$

$$p_{min} \cdot \mu_{mg} \cdot \pi \cdot d_T \cdot l = S \cdot \frac{2 \cdot M_{tmax}}{d_T}$$

S - varnost (odvisk od meje zdrsa)

l - dolžina naleganja

p_{min} - prepreči zdrs pesta po gredi



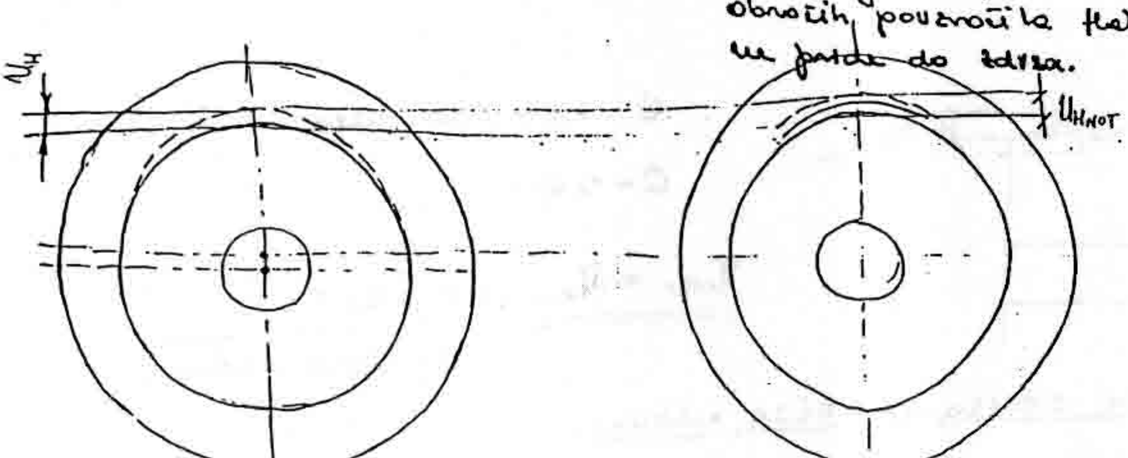
kritično mesto za zunanji obroč je na premeru d_T

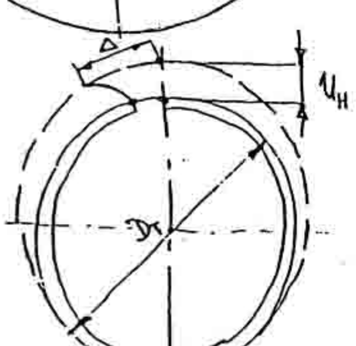
$$\boxed{\left(p \cdot \frac{Q_z^2+1}{Q_z^2-1}\right) \leq 0{,}9 \cdot \sigma_{v_z}}$$

kritično mesto za notranji obroč na premeru d_N

$$\boxed{\left|\left(-p \cdot \frac{2 \cdot Q_N^2}{Q_N^2-1}\right)\right| \leq 0{,}9 \cdot \sigma_{v_N}}$$

KOLIKŠNA MORA BITI NAJMANJŠA NADMERA: Iščemo takšen U_H da bi po nakrčenju napetost v obeh obročih povzročila tlak da ne pride do zdrsa.





$$\Delta = Obs_2 - Obs_1$$

$$\Delta = \pi \cdot (D_T + U_H) - \pi \cdot D_T$$

$$\Delta = \pi \cdot U_H$$

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

zanemarimo

$$\varepsilon_H = \varepsilon_{H_Z} - \varepsilon_{H_N}$$

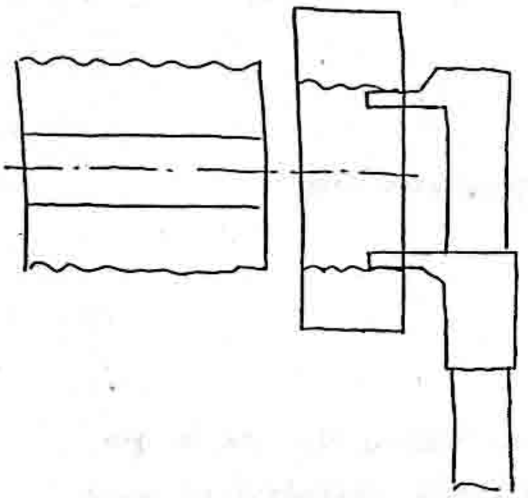
(lahko unde)

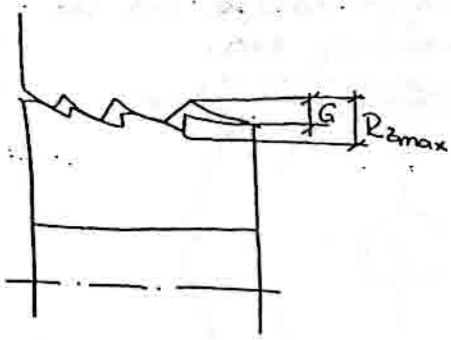
(nadmera je vecja ; ε_{H_N} je negat. deformacija)

$$\varepsilon_{H_Z} = \frac{1}{E_Z} \cdot \left[\sigma_{T_{Z_{D_T}}} - \frac{1}{\nu_Z} \cdot \sigma_{R_{Z_{D_T}}} \right] = \frac{1}{E_Z} \cdot \left[p_{min} \cdot \frac{Q_Z^2+1}{Q_Z^2-1} - \frac{1}{\nu_Z} \cdot (-p_{min}) \right]$$

$$\varepsilon_{H_N} = \frac{1}{E_N} \cdot \left[\sigma_{T_{N_{D_T}}} - \frac{1}{\nu_N} \cdot \sigma_{R_{N_{D_T}}} \right] = \frac{1}{E_N} \cdot \left[p_{min} \cdot \frac{Q_N^2+1}{Q_N^2-1} - \frac{1}{\nu_N} \cdot (-p_{min}) \right]$$

iz teh dveh enačb dobimo $\varepsilon_{H_N}, \varepsilon_{H_Z} \rightarrow \varepsilon_H \rightarrow U_{H_{min}}$





G - izgubljena mera

$G = 0{,}6 \cdot R_{Zmax}$

$$U_{min} = U_{H_{min}} + \underbrace{2 \cdot (G_Z + G_N)}_{\text{izgubljena nadmera}}$$

KOLIKO JE LAHKO NAJVEČJA NADMERA:

Z.H. Z.O

$$0{,}9 \cdot \sigma_{\nu_Z} = p_{max_Z} \cdot \frac{Q_Z^2+1}{Q_Z^2-1}$$

$p_{max_Z} =$

V posodi prikazani na sliki je zrak s tlakom 2 bar in $T = 20°C$. Kolikšen je tlak p_2, či se T zviša na 800°C?

$$\frac{p_1}{T_1} = \frac{p_2}{T_2} \qquad p_2 = \frac{p_1 \cdot T_2}{T_1} \text{ U KELVINIH!!} =$$

veličina stanja

ekstenzivne: $\underbrace{m \; V}$

intenzivne: T, p

$p \cdot v = RT \,/\cdot m$ $\qquad n\,[kmol]$

$p\,V = m\,R\,T \,/ : n$

1,2 kg zraka zavzame pri tlaku 30 bar volumen 0,08 m³. Izračunaj T, molsko maso, spec. V, in molski spec. V.? $\underbrace{R_{zraka} = 287 \; J/kgK}$

$m = 1,2$ kg
$p = 30$ bar
$V = 0,08\,m^3$

$p \cdot V = m \cdot R \cdot T \,/ : (m)$?

$30 \cdot 10^5 Pa \cdot 0,08 m^3 = 1,2 kg \cdot 287 J/kgK \cdot T$

$T =$

$v_m = \frac{V}{n} = \frac{V \cdot M}{m}$ $\qquad v = \frac{m \cdot R \cdot T}{p}$ $\qquad v = \frac{R \cdot T}{p}$

molska masa nekega plina 45 kg/kmol. Kolikšen je spec. volumen in gostota tega plina pri 75°C in 1,5 bara?

$p \cdot v_m = R_m \cdot T$

$p \cdot V = R \cdot T$

v_m

$M'' =$

$$\frac{(12,-1,-19)(5,-5,3)(}{(5,-5,3)(5,-5,3)} \quad (5,-5,3)$$

$$\frac{(60,5,-57)(5,-5,3)}{(25,25,9)}$$

$$\frac{(60,5,-57)}{(+5,5,+3)} = ?$$

$$0{,}9 \cdot \sigma_{DN} = \left| \left(-p_{max_N} \cdot 2 \cdot \frac{Q_N^2}{Q_N^2 - 1} \right) \right|$$

$$\underline{\underline{p_{max_N} =}}$$

Na mejni ploskvi morata biti oba tlaka enaka

$$p_{max} = \inf \left(p_{max_Z}, p_{max_N} \right)$$

$$\varepsilon_{HZ max} = \frac{1}{E_Z} \cdot \left[\left(p_{max} \cdot \frac{Q_Z^2 + 1}{Q_Z^2 - 1} \right) - \nu_Z \left(-p_{max} \right) \right]$$

$$\varepsilon_{HN max} = \frac{1}{E_N} \cdot \left[p_{max} \cdot \frac{Q_N^2 + 1}{Q_N^2 - 1} - \nu_N \left(-p_{max} \right) \right]$$

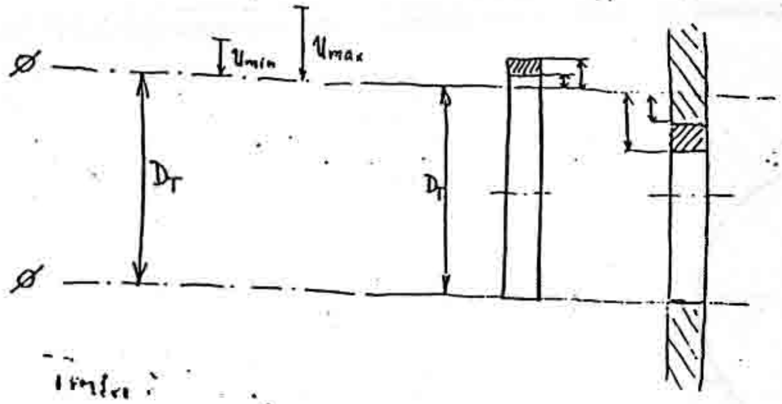
$$U_{Hmax} = \varepsilon_{HZ max} + \varepsilon_{HN max}$$

$$\underline{\underline{U_{max} = U_{Hmax} + 2 \cdot \left[0{,}6 \cdot R_{z max}^{Z} + 0{,}6 \cdot R_{z max}^{N} \right]}}$$

Izbrati je potrebno primerno toleranco : ???

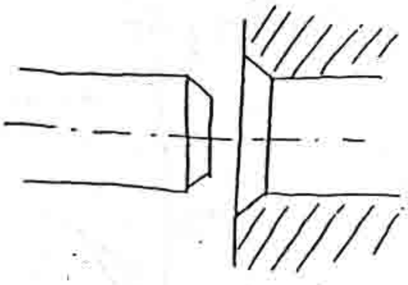
$T_{min} > U_{min}$

$T_{max} < U_{max}$



Tmin :

Priprava gredi :



Pri segrevanju obroča, ga je treba tako močno segreti da imamo nekaj rezerve. Če tega ne naredimo se nam lahko v najslabšem primeru zgodi, da nakol

Potrebno je doseči pravo temp.:

$$\alpha \cdot \Delta\vartheta \cdot D_T \geq T_{max}$$

$$\alpha \cdot \Delta\vartheta \cdot D_T = T_{max} \cdot \frac{D_T}{1000}$$

$$\Delta\vartheta = \frac{T_{max}}{\alpha \cdot 1000}$$

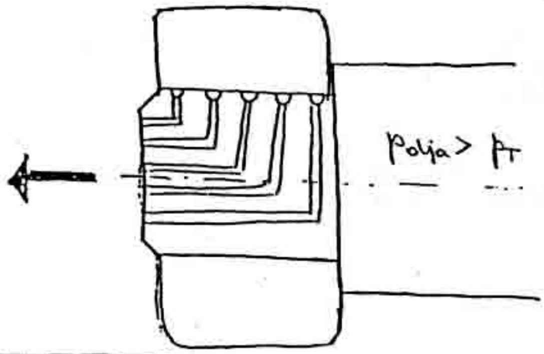
$$\vartheta_{N.O.} = \vartheta_{ok}$$

$$\vartheta_{Z.O.} = \vartheta_{ok} + \Delta\vartheta \leq \vartheta_{rekristalizacije}$$

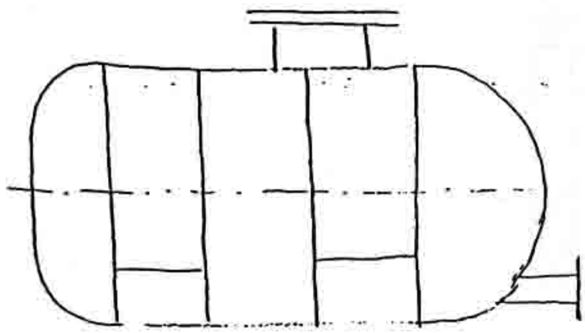
Če ne dobimo tokične rezerve je potrebno hladiti (tekoči dušik)

Snemanje:

Snemanje je mogoče le s porušitvijo, zato se redko, ker izgubimo nadmero.



TLAČNE POSODE

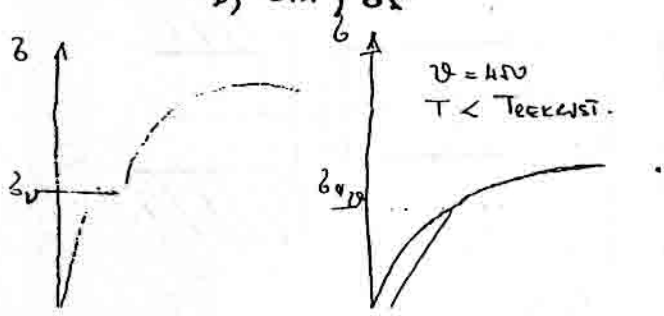


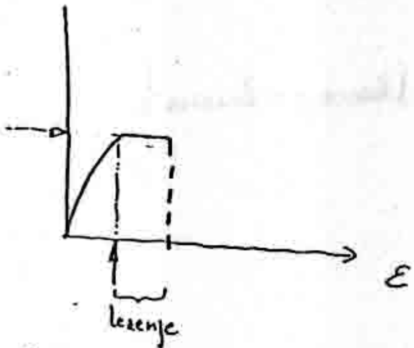
več revizijskih odprtin

Material: Č. 1202
⋮
Č. 1207

legirano jeklo [Mn, Mo, Cr-Mn]

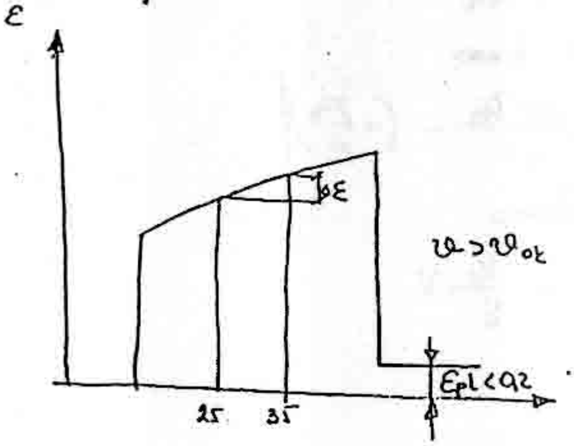
Za material garantiramo σ_v, σ_m, σ_T





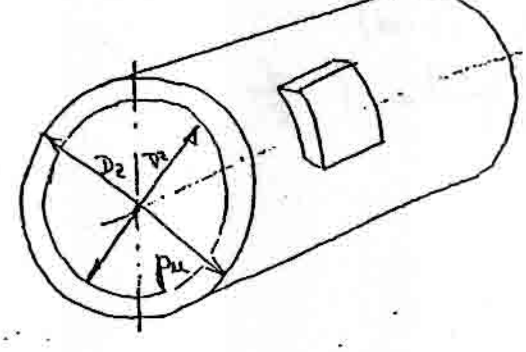
Dimenzionirati morati na mejo lezenja

Meja lezenja K, δ je tista napetost pri določeni temperaturi, ki med 25 in 35 urah preizkusa povzroči hitrost lezenja 0,001% na uro, Trajna deformacija po 45 urah obremenitve pa je manjša od 0,2%.

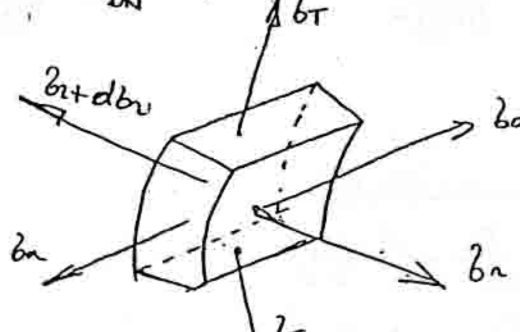


$\vartheta > \vartheta_{kr}$ $\qquad \frac{\varepsilon_t}{\Delta t} = 0{,}001\,\%/h$

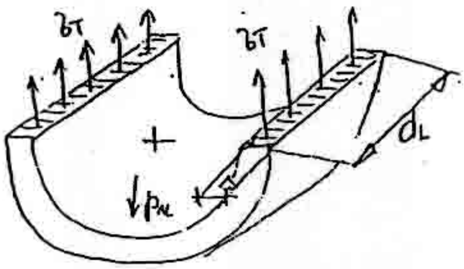
Osnova za preračun kotlne posode



$$\frac{D_z}{D_n} < 1{,}2$$



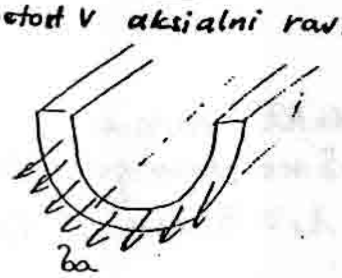
Napetost σ_T



$$\sigma_T \cdot 2 \cdot s \cdot \cancel{dL} = p_n \cdot D_n \cdot \cancel{dL}$$

$$\underline{\underline{\sigma_T = \frac{p_n \cdot D_n}{2 \cdot s}}}$$

Napetost v aksialni ravnini:

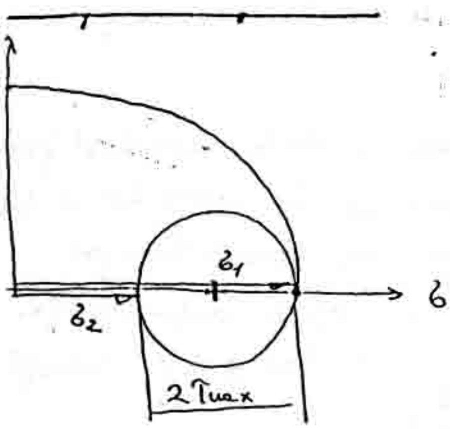


$$\sigma_a \cdot \pi \cdot d_n \cdot s = p_n \cdot \frac{\pi \cdot D_n^2}{4}$$

$$\sigma_a = p_n \cdot \frac{D_n}{4 \cdot s}$$

radialna napetost

$\sigma_r = \Big|_{-p_n}^{0}$ $\qquad \sigma_r = -p_n$



$$\sigma_p = |2\cdot\tau_{max}| = |\sigma_{max} - \sigma_{min}|$$

$$\sigma_t > \sigma_a > \sigma_r$$

$$\sigma_a = \frac{\sigma_t}{2}$$

$$\sigma_r = \sigma_{min}$$

$$\sigma_t = \sigma_{max}$$

$$\sigma_p = \left|\frac{p_n\cdot D_n}{2s} - \left(-\frac{p_u}{2}\right)\right|$$

$$\sigma_p \leq \sigma_{dop}$$

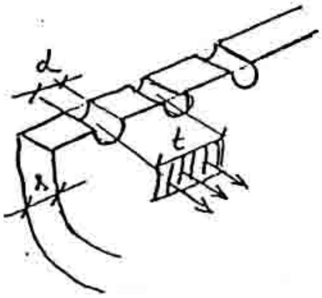
$$\sigma_{dop} = \frac{K}{S}\cdot V$$

arjena posoda:

$V = 1$ za S kvalit.

$V = 0,8$ I "

$V = 0,6$ II "



$$\sigma_t' > \sigma_t$$

$$s\cdot t \Rightarrow s(t-d)$$

$$V = \frac{s\cdot(t-d)}{s\cdot t} = 1 - \frac{d}{t}$$

KOTLOVSKA ENAČBA:

$$\sigma_p = \frac{p_n\cdot D_n}{2s} - \left(-\frac{p_u}{2}\right)$$

$$\sigma_p = \left|\frac{p_n\cdot D_n}{2\cdot s} - \left(-\frac{p_u}{2}\right)\right|$$

$$\sigma_p \leq \sigma_{dop}$$

$$\sigma_{dop} = \frac{K}{S}\cdot V$$

$$\frac{p_u\cdot D_n}{2s} - \left(-\frac{p_u}{2}\right) \leq \frac{K}{S}\cdot V$$

$$\frac{p_n D_n}{2s} = \frac{K}{S}\cdot V - \frac{p_u}{2}$$

$$p_n D_n = \left[\frac{K}{S}\cdot V - \frac{p_u}{2}\right]\cdot 2s$$

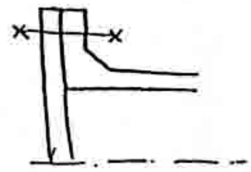
$$\boxed{s = \frac{p_u\cdot D_n}{\frac{2\cdot K\cdot V}{S} - p_u} + C_1 + C_2}$$

C_1 – dodatek zaradi možne korozije (1mm)

$s_1 > 30\,mm \Rightarrow C_1 = \phi$

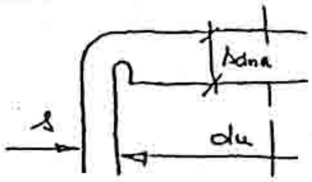
C_2 – dodatek zaradi netočnosti debeline stene.

POKROV:

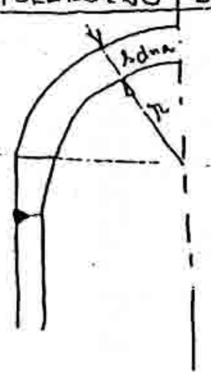


pokrov dimenzionirat
kot tankostensko lupino.

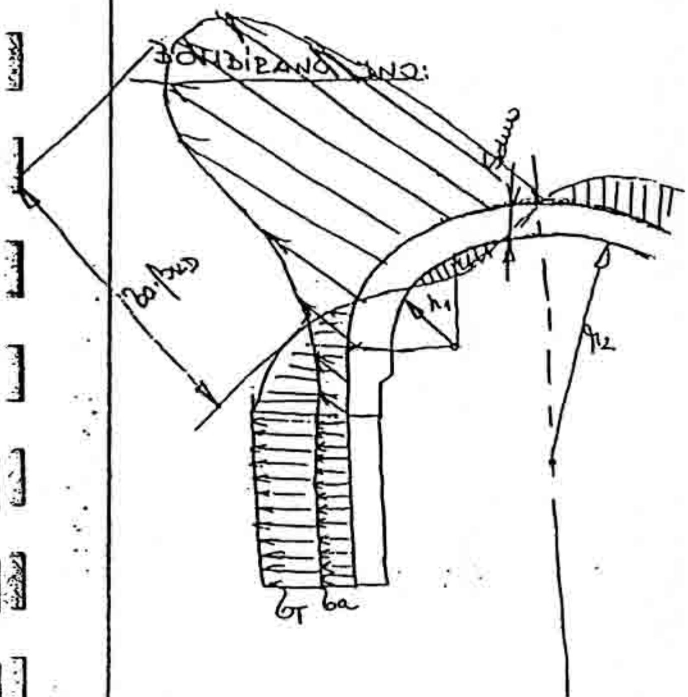
DNA:



POLKROŽNO DNO:



TORIDIRANO DNO:



$$\boxed{s_{dna} = \frac{p_u \cdot D_u \cdot \beta_{KD}}{4 \cdot \frac{K \cdot v}{S}} + C_1 + C_2}$$

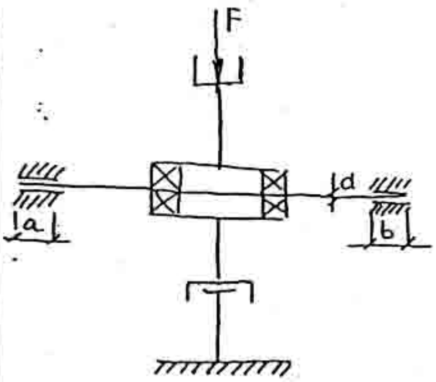
OSI IN GREDI:

Osi: prenos upogibnih napetosti in površinskih pritiskov
Gred: prenos upogibnih momentov in vrtilnih momentov

$$\left.\begin{array}{ll} \text{gred}: & M_t,\ \omega \\ \text{os}: & \omega \end{array}\right\} M_{up}$$

OSI:

1.) MIRUJOČA OS:



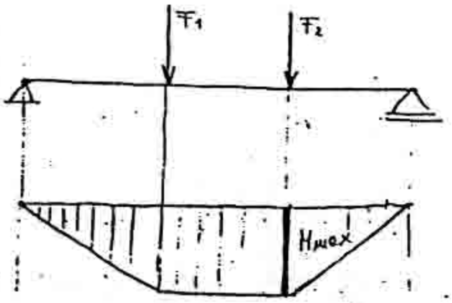
$$\sigma = \frac{F}{A}$$

$$\sigma \leq \sigma_{dop}$$

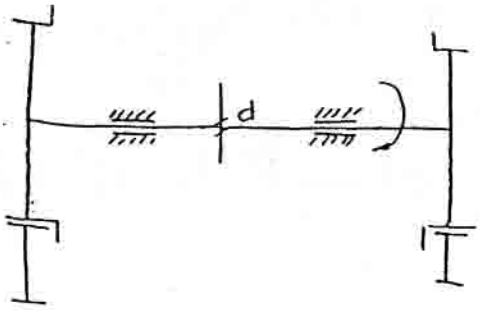
$$\sigma_{dop} = \frac{\sigma_{0,2}}{\nu}$$

$$\nu = 3 \div 5$$

obremenitev:

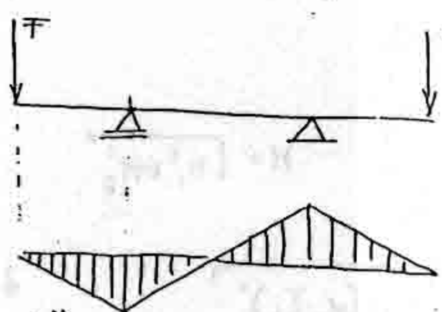


2.) ROTIRAJOČA OS:

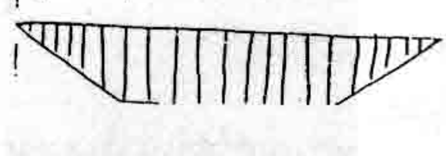


$$\sigma = \frac{F}{A}$$

obremenitev:



ali



$$\sigma_{dop} = \frac{}{\beta_k \cdot \nu}$$

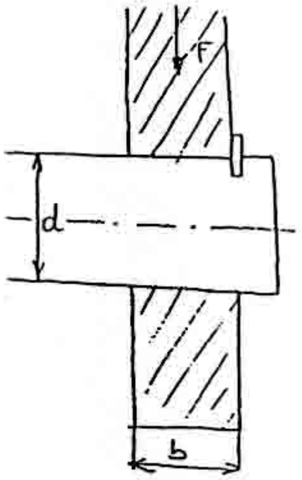
$$\nu = 1{,}5 \div 2\ (3)$$

$$\beta_k = 1 + \eta_k (\alpha_k - 1)$$

α_k - oblikovno število

η_k - faktor občutljivosti mat. na zarezni učinek

OIRĐNSKI PRITISK:



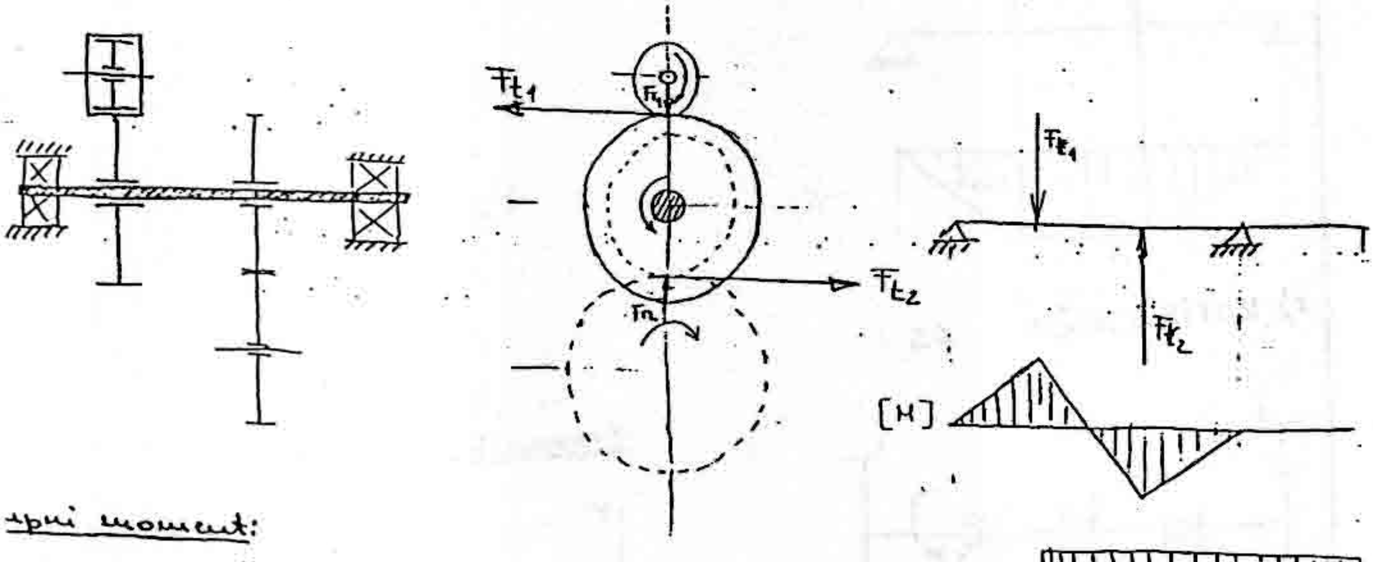
$$p = \frac{F}{A}$$

$$p \le p_{dop}$$

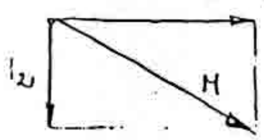
$$A = b \cdot d$$

A

) GREDI:



upni moment:



$$M = \sqrt{M_1^2 + M_2^2}$$

$$\sigma_p = \sqrt{\sigma^2 + 3(\alpha_0 \tau_t)^2}$$

$$\sigma = \frac{M}{W}$$

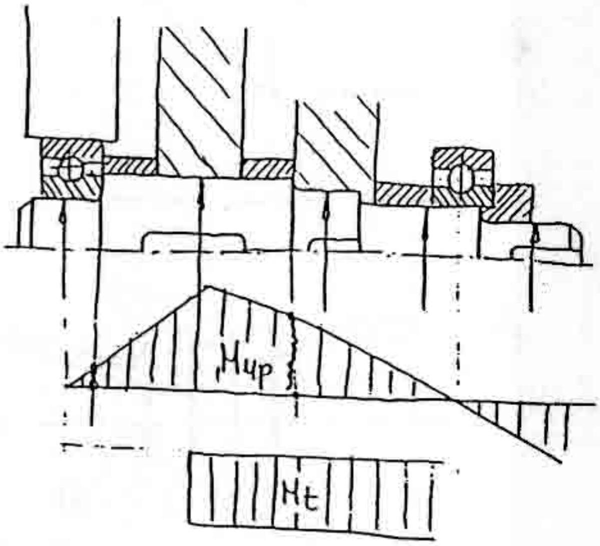
$$\tau_t = \frac{T}{W_p}$$

$$\sigma_p \le \sigma_{dop}$$

$$\sigma_{dop} = \frac{\sigma_{0,2}}{\nu}$$

- trdnostni kriterij
  - deformacije
  - lastna frekvenca
  - velikost ležajev
  - velikost grednih vezi

OBLIKOVANJE:



Kriterij porušitve:
- velikost obremenitve
- velikost prereza
- zarezni učinek

Trdnostni kriterij:

znano M_{up}, M_t

$$\sigma_{up} = \frac{M_{up}}{W_x}$$

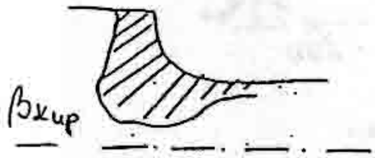
$$\tau_t = \frac{M_t}{W_p}$$

$$\sigma_p = \sqrt{\sigma^2 + 3 \cdot (\alpha_0 \cdot \tau_t)^2}$$

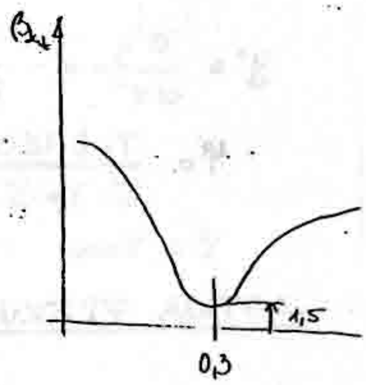
$$\sigma_p \leq \sigma_{dop}$$

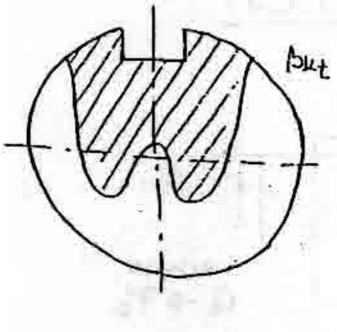
$$\sigma_{dop} = \frac{\sigma_D \cdot b_1 \cdot b_2}{\beta_k \cdot \nu}$$

$$\beta_k = 1 + \eta_k \, (\alpha_k - 1)$$



$$\beta_{kup} = \beta_{kup}\left(\frac{d}{D}, \rho\right)$$



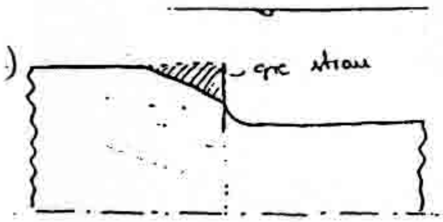


$$\sigma_p = \sqrt{(\sigma \cdot \beta_{kup})^2 + 3 \cdot (\alpha_0 \cdot \tau_t \cdot \beta_{kt})^2}$$

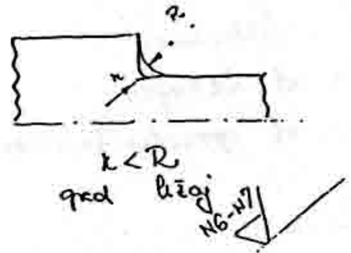
za jeklo: $\alpha_0 = \dfrac{\sigma_{upD}}{1{,}73 \, \tau_{tD}}$

Mat. gredi: Č.0360, Č.0460, Č.1530.

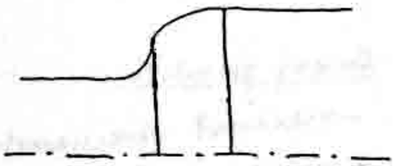
)



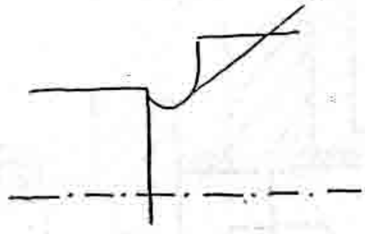
b)



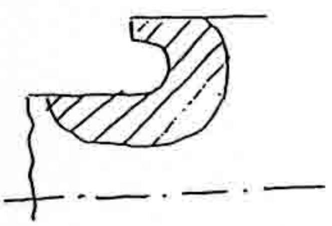
c)



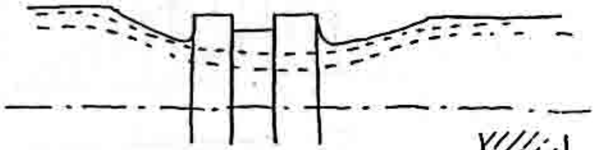
d)



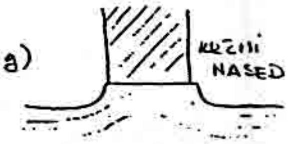
e)



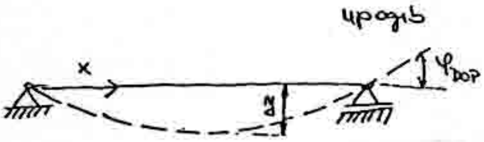
f)



g)



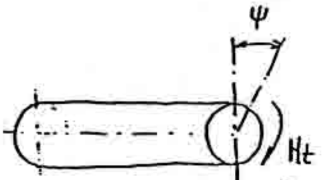
DEFORMACIJE:



$$y'' = \frac{d^2y}{dx^2} = -\frac{M_{up}}{E \cdot J_x}$$

$$\varphi = \frac{T \cdot l \cdot 180}{G \cdot J_p \cdot \pi} \quad [°C]$$

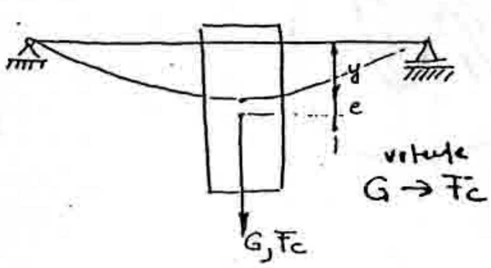
$$\varphi < \varphi_{dop}$$



$$\psi = \frac{M_t \cdot l}{G \cdot J_p}$$

$$\psi \leq \psi_{dop}$$

ASTNA FREKVENCA:



$$F_c = c \cdot y = m \cdot \omega^2 (y + e)$$

$$c \cdot y = m\omega^2 y + m\omega^2 e$$

$$y \cdot (c - m\omega^2) = m\omega^2 e$$

$$y = \frac{m\omega^2 e}{\ldots} \qquad m\omega^2 \qquad \omega = \ldots$$

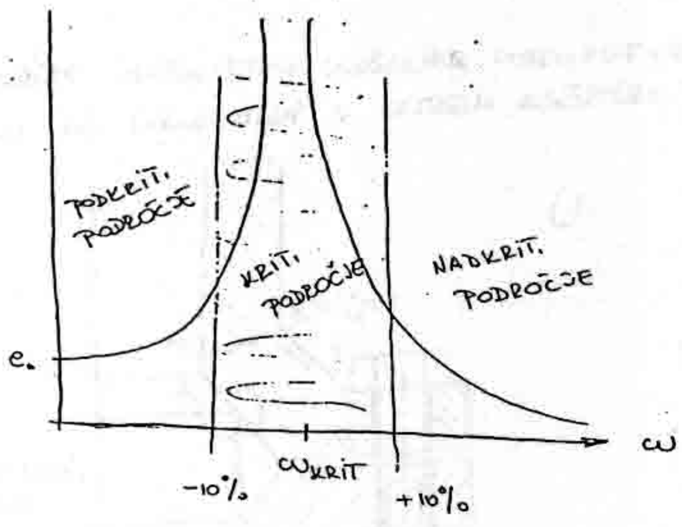
$$\omega_{krit} = \sqrt{\frac{c}{m}} \quad \text{(upogib)}$$

$$\omega_{krit} = \sqrt{\frac{c_t}{J_m}} \quad \text{(torzija)}$$

$$n_{krit} = \frac{k}{2\pi} \cdot \sqrt{\frac{c}{m}}$$

k – faktor načina uležajenja

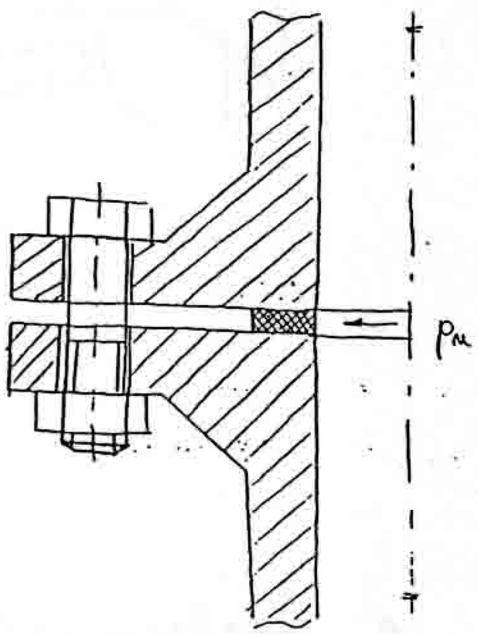
$$\boxed{y = \frac{m\omega^2 e}{(c - m\omega^2)}}$$



PRIROBIČNE ZVEZE TLAČNIH POSOD:

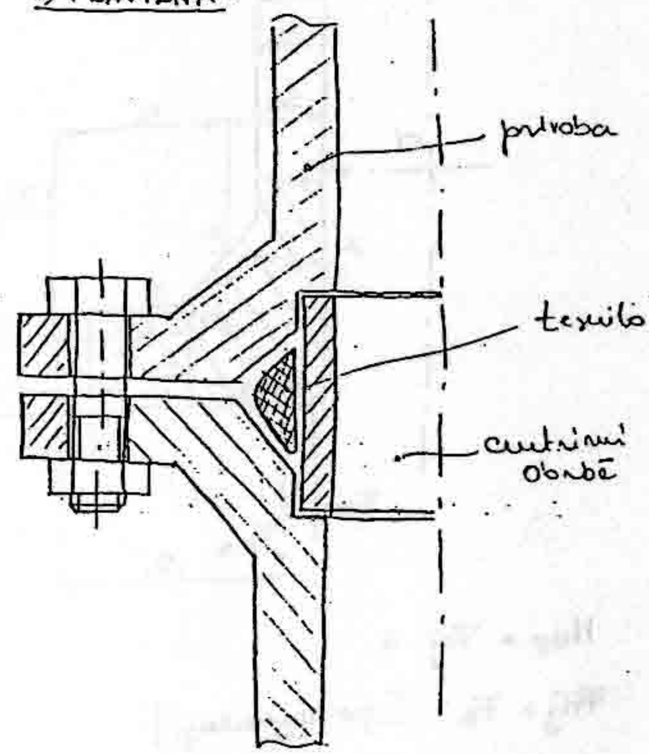
24.| SKICIRAJ ~~STRD~~ PRAVILNO IN NEPRAVILNO LEGO GUMIJASTEGA TESNILA V PRIROBIČNI ZVEZI !

a) NEPRAVILNA:



- obstojati mora zračnost zaradi kontroliranega stiskanja tesnila
- tlak tesnila na pritiska na steno
- pride do iztiskanja tesnila

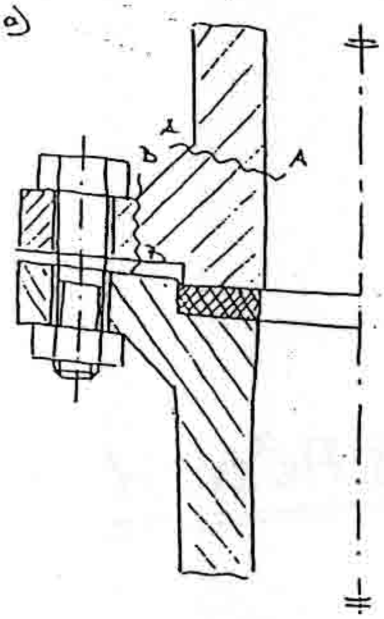
b) PRAVILNA:



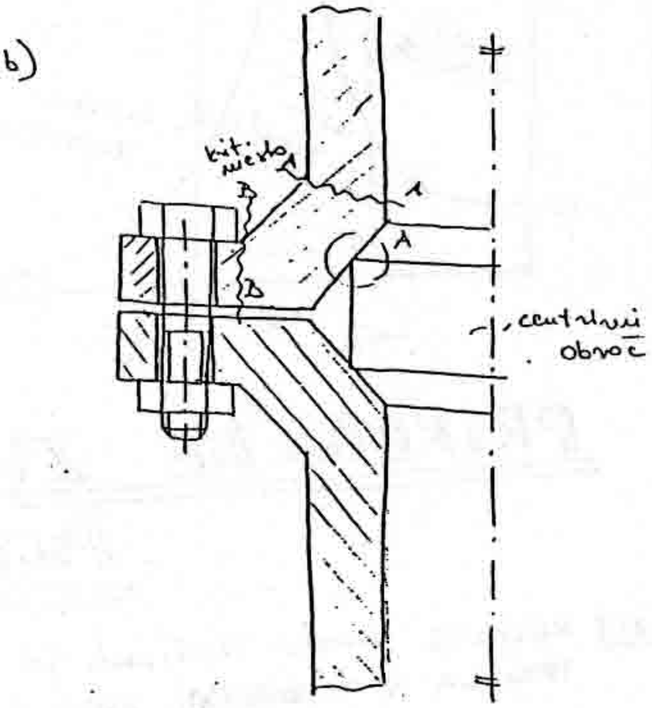
- centrirni obroč omogoča boljše nalaganje
- obe prirobi sta enaki - manjši stroški izdelave

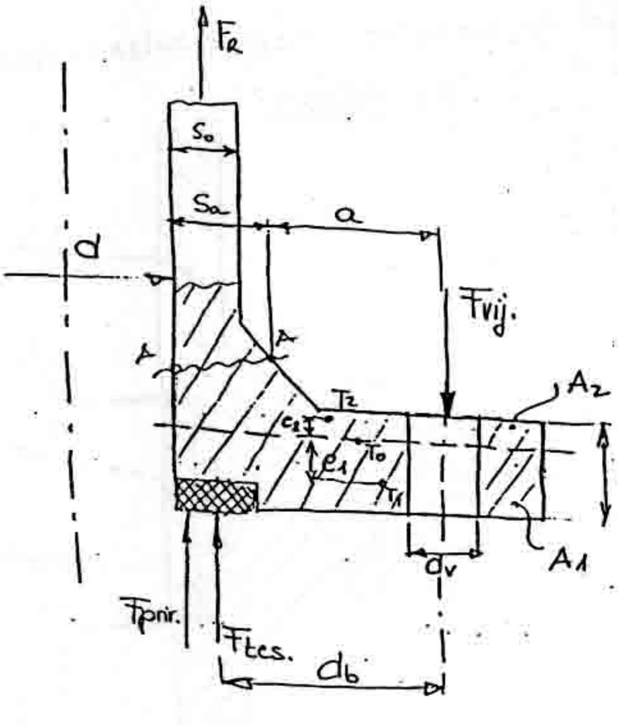
... TESNILOM ZATESNJEN ZVIJAČEN NADTLAČNI PRIROBNIČNI SPOJ DVEH LITIH CEVI, DOLOČI KRITIČNA MESTA V PRIROBNICI IN NAČIN DIMENZIONIRANJA LE-TEH!

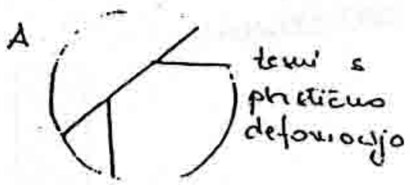
a)



b)







$M_{up} = F_{vij} \cdot a$

$F_{vij} = F_B$ [po vgradnji]

F_B – sila tesnenja v pogonu

$F_B = \pi \cdot d_b \cdot k_0 \cdot k_B$

k_0 – karakteristika tesnila

k_B – deformacijski odpor tesnila

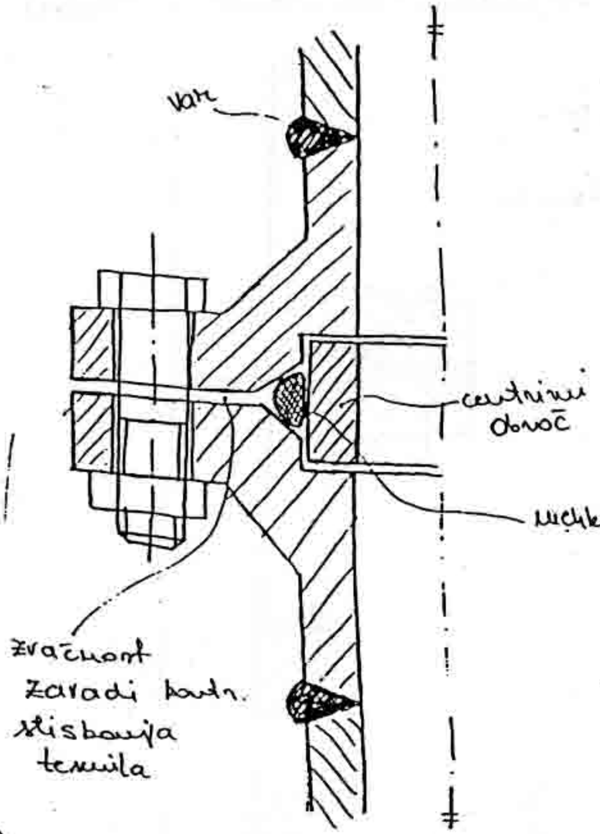
$$\sigma_{up} = \frac{M_{up}}{W_{A-A}}$$

$$W_{A-A} = 2\pi \cdot \left[2A_1 \cdot e_1 + \frac{1}{8}(d + s_a) \cdot (s_a^2 - s\ldots\right.$$

$\sigma_{up} \le \sigma_{up\,dop}$

$$\sigma_{up\,dop} = \frac{0{,}8 \cdot \sigma_D}{S}$$

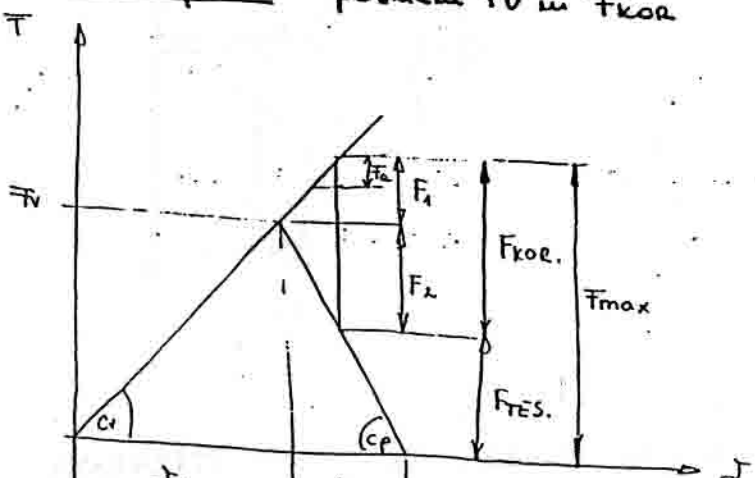
... NADILAČNI IN TESNJENI Z MEHKIM TESNILOM.



27.) SKICIRAJ VARJENO PRIROBNIČNO ZVEZO CEVI ZATESNJENIH Z MEHKIM TESNILOM! KAKO KONTROLIRAMO VIJAKE

skica ista kot pri vpr. 26

Kontrola vijakov: poznamo F_V in F_{KOR}



$F_{max} = F_V + F_1$

$F_1 = F_{KOR} \cdot \frac{c_v}{(c_v + c_p)}$

$\sigma_{max} = \frac{F_{max}}{\frac{\pi \cdot d_1^2}{4}}$

$M_t = F_V \cdot tg(\alpha + \rho') \cdot \frac{d_2}{2}$

$\tau_t = \frac{M_t}{W_p}$

$\sigma_p = \sqrt{\sigma_{max}^2 + 3 \cdot \tau_t^2}$

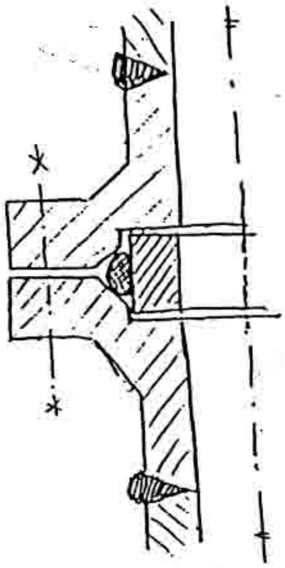
$\sigma_p \leq \sigma_{dop}$

$\sigma_{dop} = 0{,}6 \cdot \sigma_{T}$

$F_a = \frac{1}{2} F_1$

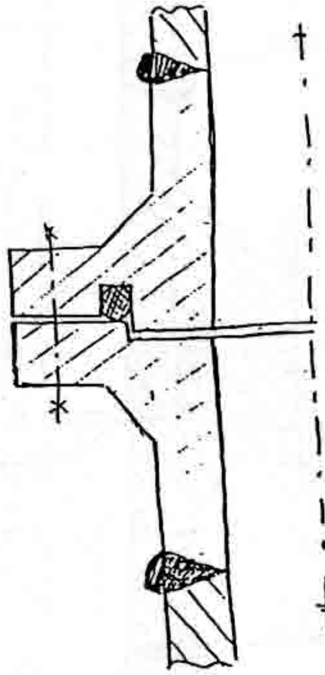
$\sigma_a = \frac{F_a}{\frac{\pi d_1^2}{4}}$ $\quad \sigma_{a\,dop} = 30 \div 70 \frac{N}{mm^2}$

) SKICIRAJ ŠTIRI IZVEDDE VARJENE PRIROBNICE TESNJENE S TRDIMI IN MEHKIMI TESNILI.

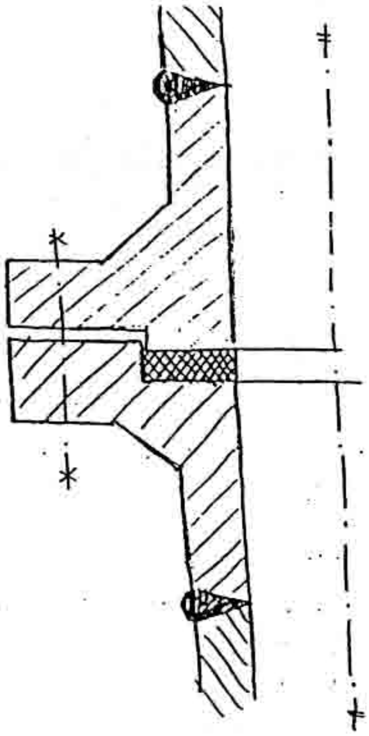


b)

(a,b) mehko tesnilo

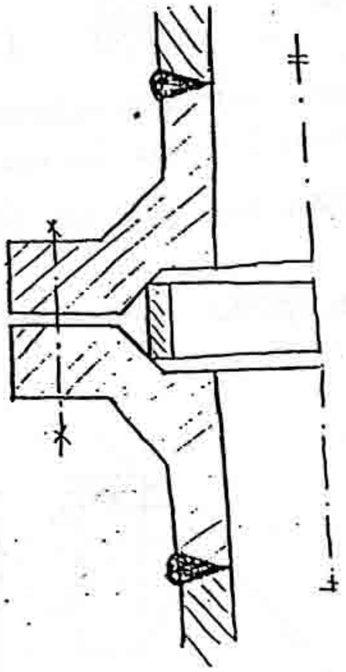


)

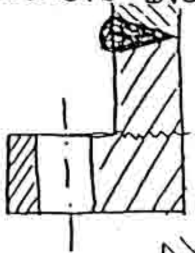


d)

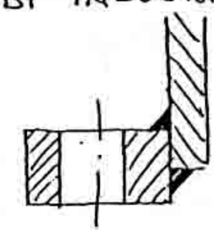
(c,d) trdi tesnili



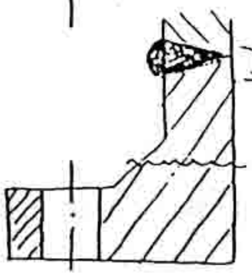
SKICIRAJ DVE DOBRI IN DVE SLABI IZVEDBI VARJENIH PRIROBNIC



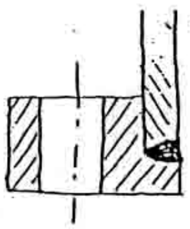
Dobra: var ji izven C.N.U.N.



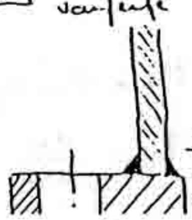
SLABA: notranje varjenje



Dobra: var je izven C.N.U.N.



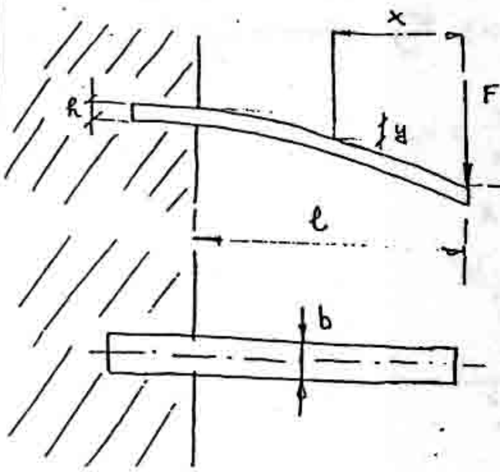
SLABA: notranje varjenje



NAJSLABŠA:
- notranje varjenje
- var v C.N.U.N.

VZMETI:

* UPOGIBNA LISTNATA VZMET, DOLOČI IZKORISTEK, IN ALGORITEM DIMENZ.



deformacija vzmeti na poljubnem mestu:

$$y = \frac{1}{6} \cdot \frac{F \cdot l^3}{E \cdot I} \cdot \left(2 - 3\frac{x}{l} + \frac{x^3}{l^3}\right)$$

$$I = \frac{b \cdot h^3}{12}$$

$$f_{max} = \frac{F \cdot l^3}{3 \cdot E \cdot I}$$

Alg. dimenz.

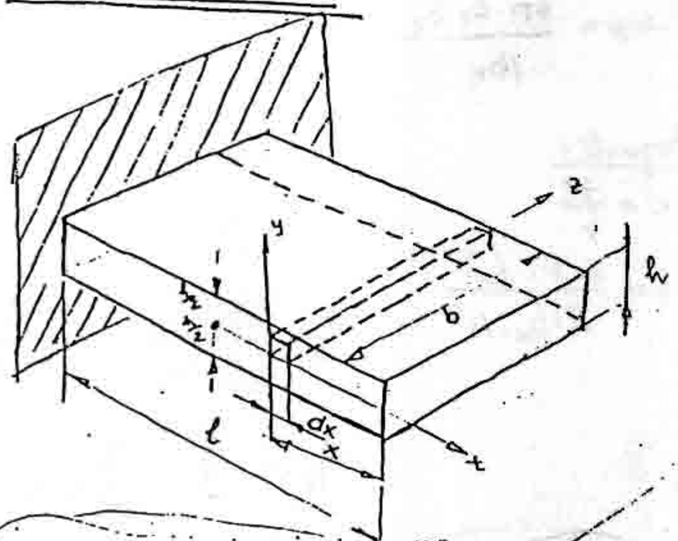
$$\sigma_{up} = \frac{M_{up}}{W}$$

$$\sigma_{up} \leq \sigma_{up\,dop}$$

$$M_{up} = F \cdot x$$

$$W = \frac{b \cdot h^2}{6}$$

IZKORISTEK:



$$A_{max} = \frac{\sigma_{max}^2 \cdot V}{2E} = \frac{\left(\frac{M}{W}\right)^2 \cdot V}{2E}$$

$$A_{max} = \frac{F^2 l^2 \cdot b \cdot h \cdot l}{\frac{b^2 \cdot h^4}{36} \cdot 2 \cdot E}$$

$$A_{max} = \frac{18 \cdot F^2 \cdot l^3}{b \cdot h^3 \cdot E}$$

$$\eta_V = \frac{A}{A_{max}} = \frac{\int_V \sigma^2 \frac{dV}{2E}}{\sigma_{max}^2 \cdot \frac{V}{2E}}$$

$$A = \frac{1}{2E} \cdot \int_V \frac{F^2 x^2}{\left(\frac{b \cdot h^3}{12 y}\right)^2} dV = \frac{1}{2E} \cdot \int_V \frac{F^2 x^2 \cdot 144 \cdot y^2}{b^2 \cdot h^6}$$

$$A = \frac{72 \cdot F^2}{E b^2 h^6} \int_0^l x^2 dx \cdot \int_{-\frac{h}{2}}^{\frac{h}{2}} y^2 dy \cdot \int_0^b dz$$

$$A = \frac{72 F^2}{E b^2 h^6} \cdot \frac{1}{3} l^3 \cdot \frac{1}{3} \cdot \frac{h^3}{4} \cdot b$$

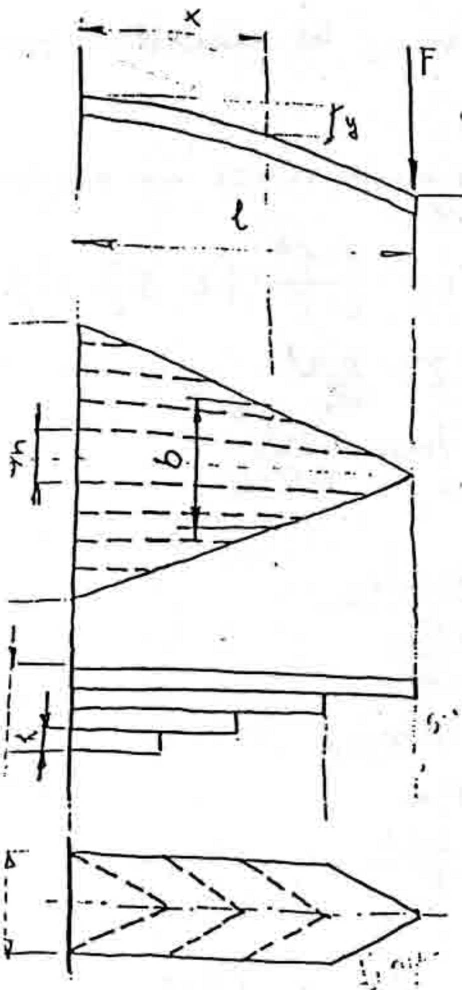
$$A = \frac{2 \cdot F^2 \cdot l^3}{E \cdot b \cdot h^3}$$

$$\eta = \frac{2 \cancel{F^2 \cdot l^3}}{\cancel{E \cdot b \cdot h^3}} \cdot \frac{\cancel{b \cdot h^3 \cdot E}}{18 \cdot \cancel{F^2 \cdot l^3}}$$

$$\eta = \frac{2}{18} = \frac{1}{9}$$

$$\eta = \frac{1}{9}$$

... NO VPUSIDNO VZMET, DOLOČI SILNO IZKORIŠČENOST,
TER ALGORITEM DIMENZIONIRANJA:



algoritem dimenzioniranja:

poznam: F, dimenzije l, b, h

$$\sigma_x = \frac{M_x}{W_x} = k$$

$$M_x = F \cdot x$$

$$W_x = \frac{b_x \cdot h^2}{6}$$

$$\sigma_x = \frac{F \cdot x}{\frac{b_x \cdot h^2}{6}}$$

$$\sigma_x \le \sigma_{dop}$$

$$\sigma_{dop} = \frac{\sigma_T \cdot b_1 \cdot b_2}{\beta_k}$$

togosti:

$$c = \frac{F}{f}$$

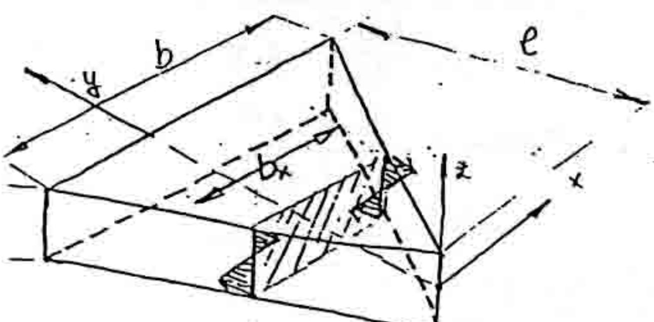
$$f = \frac{6 \cdot F \cdot l_x^2}{E \cdot b_x \cdot h^3}$$

$$\eta_v = \frac{6 F^2 \cdot l^3}{b \cdot h^3 \cdot E} \cdot \frac{b \cdot h^3 \cdot E}{9 F^2 l^3}$$

$$\eta_v = \frac{6}{9} = \frac{2}{3}$$

$$\eta_v = \frac{2}{3}$$

KORISTEK:



$$\frac{b_x}{y} = \frac{b}{l}$$

$$b_x = \frac{y \cdot b}{l}$$

$$\sigma = \frac{M}{J_x} \cdot z = \frac{F \cdot y}{\frac{b_x \cdot h^3}{12}} \cdot z = \frac{F \cdot y \cdot z \cdot 12 \cdot l}{y \cdot b \cdot h^3}$$

$$\sigma = \frac{F \cdot z \cdot 12 \cdot l}{b \cdot h^3}$$

$$= \frac{\int_V \frac{\sigma^2}{2E} \cdot dV}{\frac{\sigma^2_{max}}{2E} \cdot V} = \frac{A}{A_{max}}$$

$$A = \frac{144 \cdot F^2 \cdot l^2}{b^2 \cdot h^6 \cdot 2E} \cdot \int_{-\frac{b_x}{2}}^{\frac{b_x}{2}} dx \int_0^l y^2 dy \int_{-\frac{h}{2}}^{\frac{h}{2}} z^2 dz$$

$$\cancel{A = \frac{144 F^2 l^2}{b^2 h^6 \cdot 2E} \cdot b \cdot l \cdot \frac{1}{3} \cdot \frac{h^3}{4}}$$

$$A = \frac{3 F^2 \cdot l^3}{b \cdot h^3 \cdot E}$$

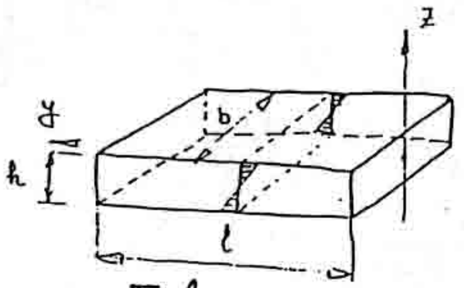
$$max = \frac{F^2 \cdot l^2}{\frac{b^2 \cdot h^4}{36}} \cdot \frac{b \cdot h \cdot l}{2 \cdot 2E}$$

$$max = \frac{9 \cdot F^2 \cdot l^3}{b \cdot h^3 \cdot E}$$

*) UPOGIBNA PLOŠČATE KONZOLNE VZMETI

princip dimenzioniranja isti kot pri upogibni trikotni vzmeti

IZKORISTEK:



$$\eta_v = \frac{\int_V \frac{\sigma^2}{2E}\cdot dV}{\frac{\sigma_{max}^2}{2E}\cdot V} = \frac{A}{A_{max}}$$

$$\sigma = \frac{M}{J_x}\cdot z = \frac{F\cdot y}{\frac{b\cdot h^3}{12}}\cdot z$$

$$\sigma_{max} = \frac{F\cdot l}{\frac{b\cdot h^2}{6}}$$

$$A = \frac{1}{2E}\cdot\frac{12^2\cdot F^2}{b^2\cdot h^{3\cdot 2}}\cdot\int_{-\frac{b}{2}}^{\frac{b}{2}} dx\cdot\int_0^l y^2 dy\cdot\int_{-\frac{h}{2}}^{\frac{h}{2}} z^2 dz$$

~~A_{max} =~~

$$A_{max} = \frac{F^2 l^2\cdot b\cdot h\cdot l}{2E\cdot\frac{b^2h^4}{36}}$$

$$A = \frac{144 F^2}{2Eb^2h^6}\cdot b\cdot\frac{1}{3}l^3\cdot\frac{1}{3}\cdot\frac{h^3}{4} =$$

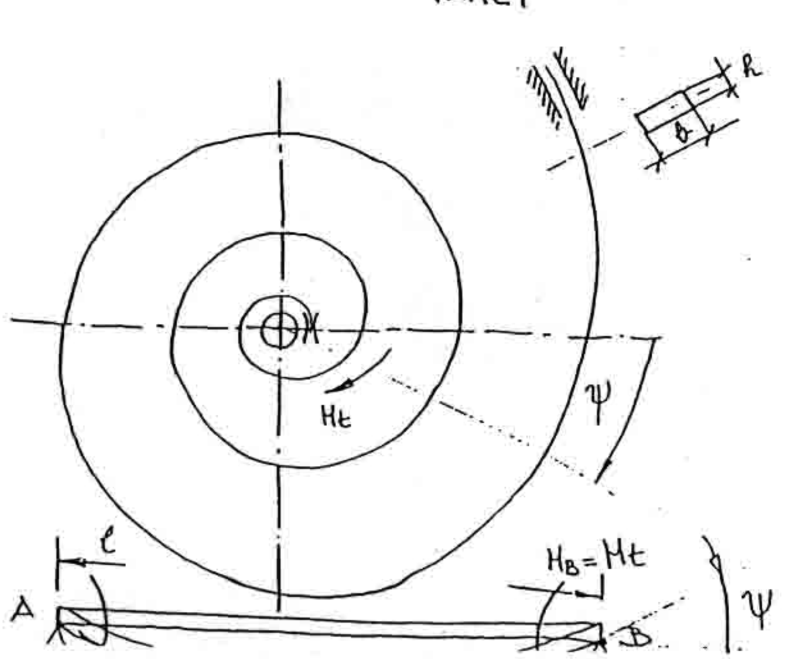
$$A = \frac{2F^2 l^3}{E b\cdot h^3}$$

$$A_{max} = \frac{18 F^2 l^3}{E\cdot b\cdot h^3}$$

$$\eta_v = \frac{2\cancel{F^2 l^3}}{\cancel{E b h^3}}\cdot\frac{\cancel{E b h^3}}{18\cdot\cancel{F^2 l^3}}$$

$$\eta = \frac{1}{9}$$

*) UPOGIBNA SPIRALNA VZMET



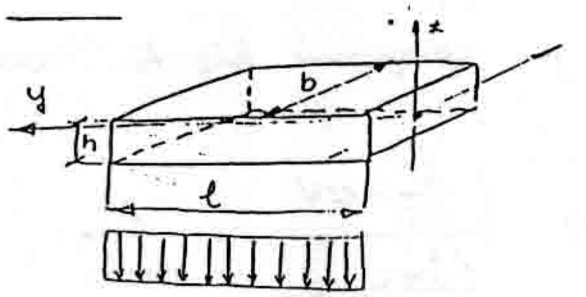
$$\psi = \frac{M_b\cdot l}{E\cdot J_x}$$

$$c = \frac{M_b}{\psi} = \frac{J_x\cdot E}{l}$$

$$\sigma_{up} = \frac{M_b}{W_x} = \frac{M_b}{\frac{b\cdot h^2}{6}}$$

$$\sigma_{up} \leq \sigma_{up\,dop}$$

$$\sigma_{dop} = \frac{\sigma_0\cdot b_1\cdot b_2}{\beta_k}$$



$$\eta_v = \frac{\ldots}{\frac{\sigma_{max}^2}{2E} \cdot V} = \frac{\ldots}{A_{max}}$$

$$\sigma = \frac{M_{up}}{J_x} \cdot z = \frac{M_t}{\frac{b \cdot h^3}{12}} \cdot z$$

$$A = \frac{1}{2E} \cdot \frac{M_t^2 \cdot 144}{b^2 \cdot h^6} \cdot \int_{-\frac{b}{2}}^{\frac{b}{2}} dx \int_0^{\ell} dy \int_{-\frac{h}{2}}^{\frac{h}{2}} z^2 dz$$

$$A = \frac{144 \cdot M_t^2}{2E\, b^2 h^6} \cdot b \cdot \ell \cdot \frac{1}{3} \cdot \frac{h^3}{4}$$

$$\underline{\underline{A = \frac{6 \cdot M_t^2 \ell}{E \cdot b \cdot h^3}}}$$

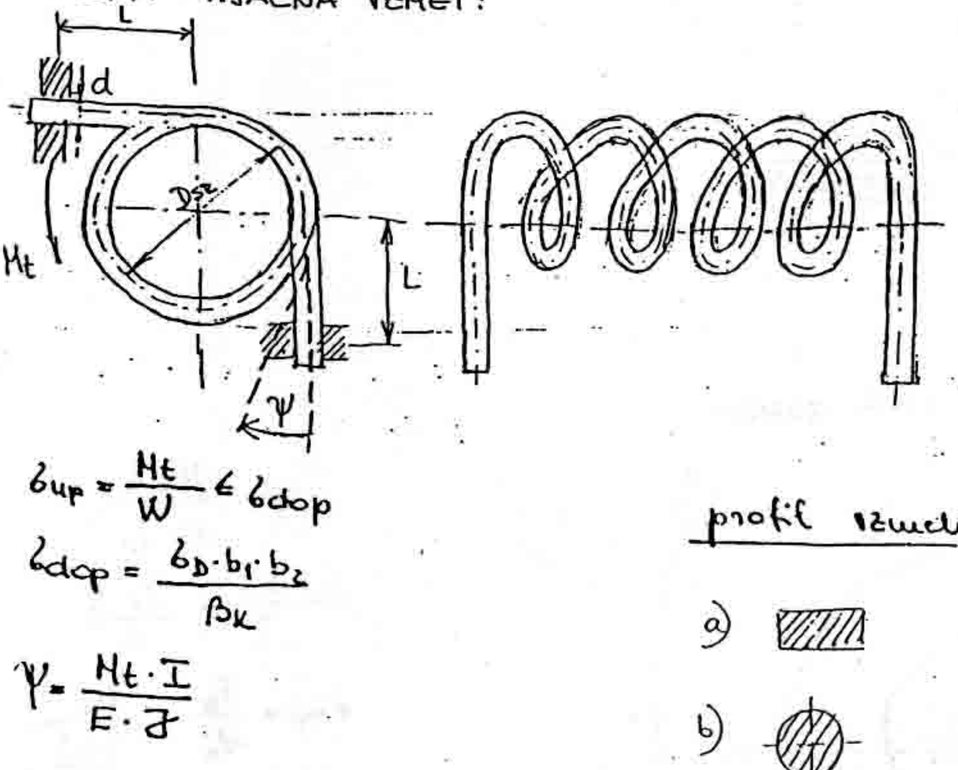
$$A_{max} = \frac{M_t^2 \cdot b \cdot h \cdot \ell}{\frac{b^2 h^4}{36} \cdot 2E}$$

$$\underline{\underline{A_{max} = \frac{18\, M_t^2 \cdot \ell}{b \cdot h^3 \cdot E}}}$$

$$\eta_v = \frac{6 \cdot M_t^2 \cdot \ell \cdot b \cdot h^3 \cdot E}{E \cdot b \cdot h^3 \cdot 18 \cdot M_t^2 \cdot \ell}$$

$$\underline{\underline{\eta_v = \frac{1}{3}}}$$

UPOGIBNA VIJAČNA VZMET:



$$\sigma_{up} = \frac{M_t}{W} \leq \sigma_{dop}$$

$$\sigma_{dop} = \frac{\sigma_D \cdot b_1 \cdot b_2}{\beta_k}$$

$$\psi = \frac{M_t \cdot l}{E \cdot J}$$

$$l = \pi \cdot D_{sr} \cdot i$$

J - vztrajnostni moment

i - število ovojev vzmeti

profil vzmeti:

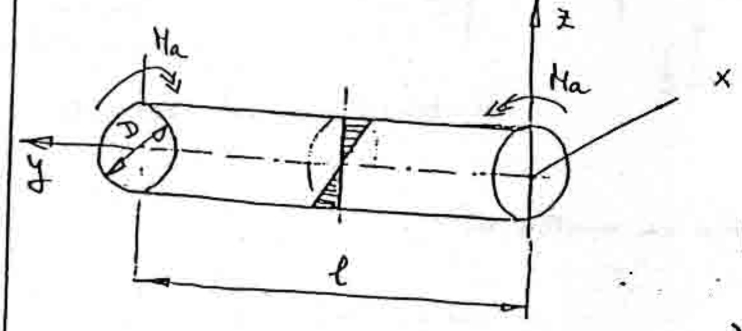
a)

b)

a) ploščati profil:

* glej str. 12.

b) okrogel profil:



$$\eta_v = \frac{\int_V \frac{\sigma^2}{2E}\, dV}{\frac{\sigma_{max}^2}{2E}\cdot V} = \frac{A}{A_{max}}$$

$M_{up} = M_t$

$$\sigma = \frac{M_{up}}{J_x}\cdot z = \frac{M_t \cdot z}{\frac{\pi \cdot d^4}{64}}$$

$$A = \frac{64^2 \cdot M_t^2}{\pi^2 \cdot d^8 2E}\int_V z^2\, dV$$

$$A = \frac{64^2\, M_t^2}{\pi^2 \cdot d^8 \cdot 2E}\cdot \iiint r^2 \sin^2\varphi \cdot r \cdot dr\, d\varphi\, dy$$

$x = r\cos\varphi$

$z = r\sin\varphi$

$y = y$

$J(x,z) = r$

$$A = \frac{64^2 \cdot M_t^2}{2E\cdot \pi^2 \cdot d^8}\cdot \int_0^{\frac{d}{2}} r^3\, dr \cdot \int_0^{2\pi} \sin^2\varphi\, d\varphi \cdot \int_0^{\ell} dy$$

$$A = \frac{64^2 \cdot M_t^2}{2E\cdot \pi^2 \cdot d^8}\cdot \frac{1}{4}\cdot r^4\Big|_0^{\frac{d}{2}} \cdot \left[\frac{1}{2}\varphi - \frac{1}{4}\sin 2\varphi\right]_0^{2\pi} \cdot y\Big|_0^{\ell}$$

$$A = \frac{64^2 \cdot M_t^2}{2E\cdot \pi^2 \cdot d^8}\cdot \frac{1}{4}\cdot\frac{d^4}{16}\cdot \frac{1}{2}\cdot 2\pi \cdot \ell$$

$$A = \frac{32 \cdot M_t^2 \cdot \ell}{\pi \cdot d^4 \cdot E}$$

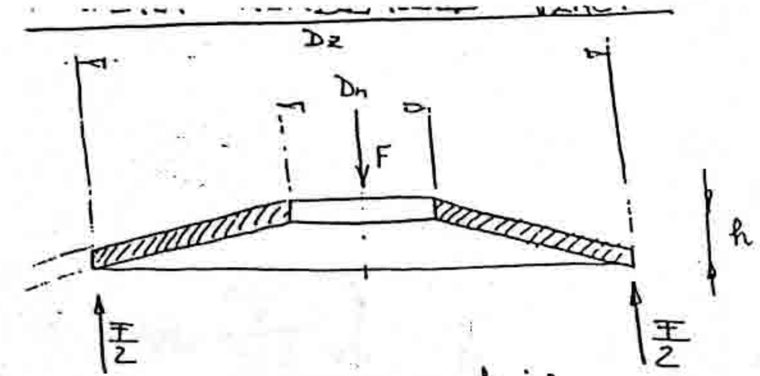
$$A_{max} = \frac{M_t^2 \cdot \frac{\pi\cdot d^2}{4}\cdot \ell}{\frac{\pi^2 \cdot d^6}{32^2}\cdot 2E}$$

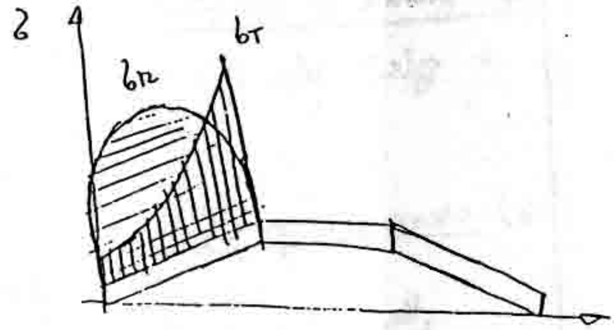
$$A_{max} = \frac{128\, M_t^2 \cdot \ell}{\pi \cdot d^4 \cdot E}$$

$$\eta_v = \frac{A}{A_{max}} = \frac{32 \cdot \cancel{M_t^2 \cdot \ell} \cdot \cancel{\pi \cdot d^4 \cdot E}}{\cancel{\pi \cdot d^4 \cdot E}\; 128\, \cancel{M_t^2 \cdot \ell}}$$

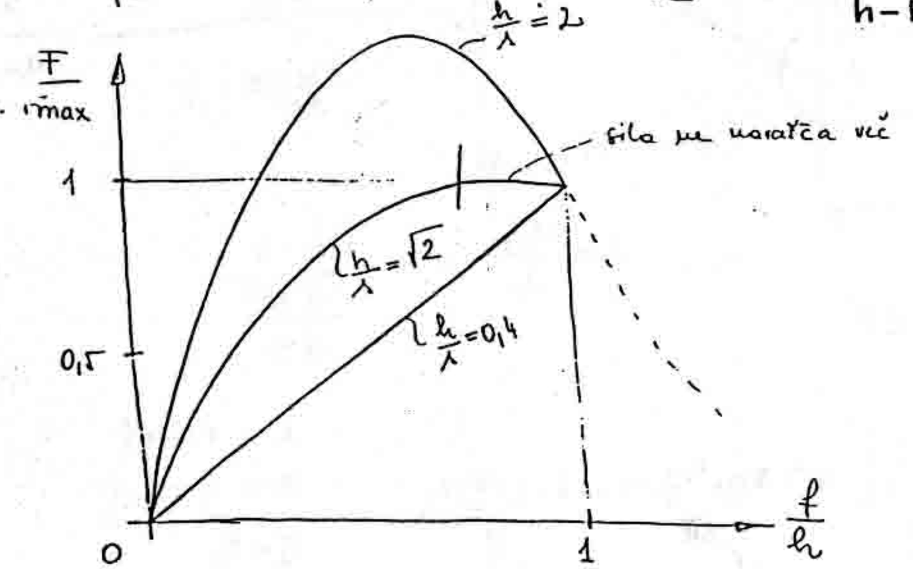
$$\eta_v = \frac{32}{128}$$

$$\eta_v = \frac{1}{4}$$

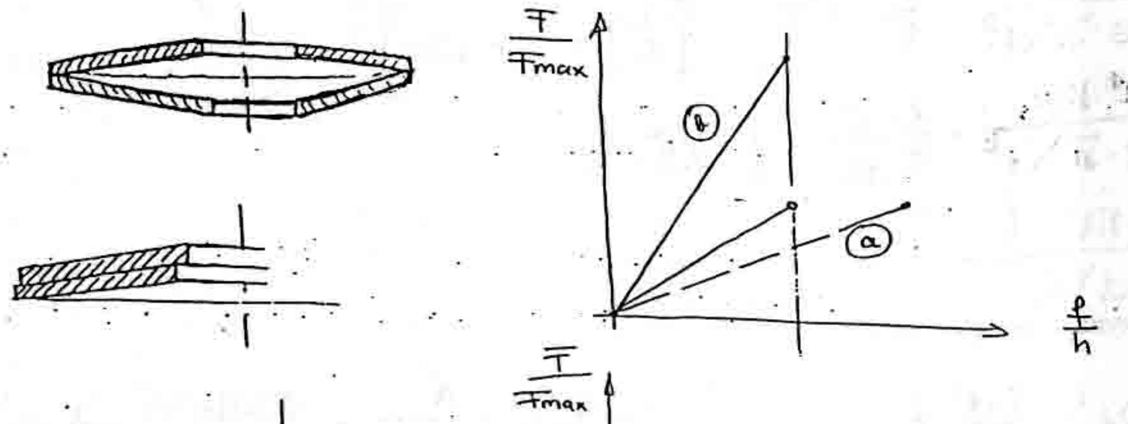




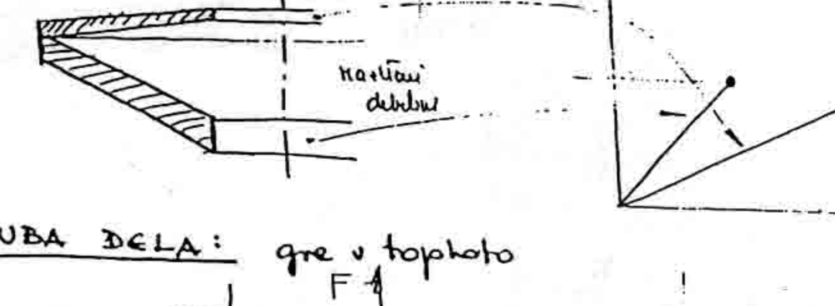
h-bombiranost vzmeti



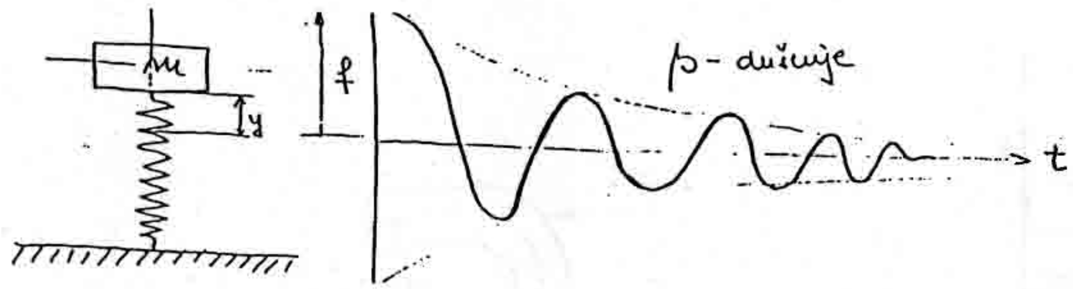
sestavljanjem k vzmeti v pakete dobim drugačno karakt.



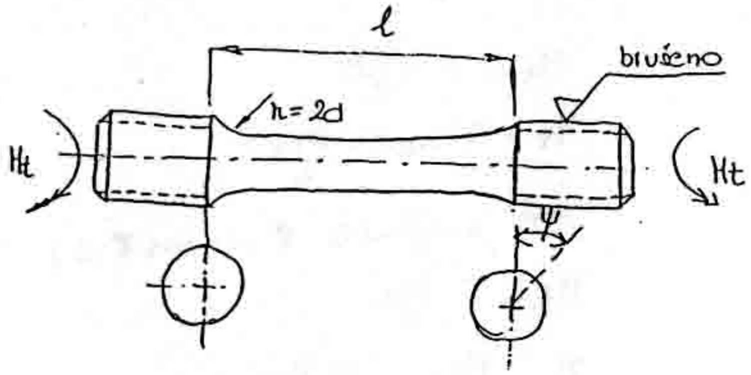
IZGUBA DELA: gre v toploto



$A_{VL} > A_{VR}$



* TORZIJSKA PALIČNA VZMET:



alg. dimenz.:

$$\psi = \frac{Mt \cdot l}{G \cdot I_p}$$

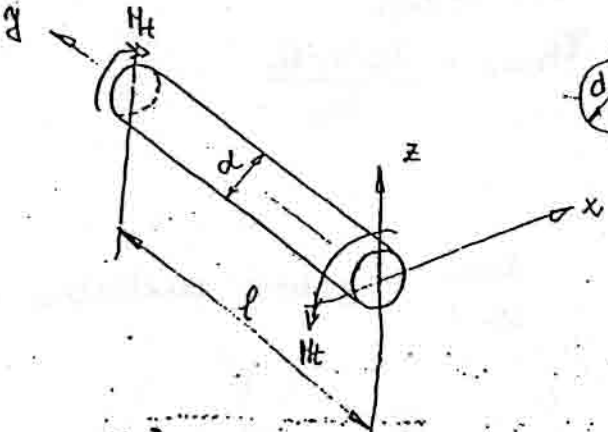
$$\tau_t = \frac{M_t}{W_p}$$

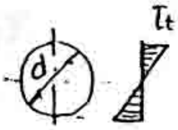
$$\tau_t \leq \tau_{t\,dop}$$

$$\tau_{t\,dop} = \frac{\tau_D \cdot b_1 \cdot b_2}{\beta_k}$$

$$c = \frac{G \cdot I_p}{l}$$

IZKORISTEK:





$$\eta_v = \frac{\int_V \cdot \frac{\tau_t^2}{2G} \cdot dV}{\frac{\tau_{t\,max}^2}{2G} \cdot V} = \frac{A}{A_{max}}$$

$$\tau_t = \frac{Mt}{I_p} \cdot r$$

$$\boxed{\tau_t = \frac{Mt \cdot r}{\frac{\pi \cdot d^4}{32}}}$$

$$A = \frac{Mt^2}{\frac{\pi^2 \cdot d^8}{32^2} \cdot 2G} \cdot \int_V r^2 dV$$

$x = r\cos\varphi$

$z = r \cdot \sin\varphi$

$y = y$

$J = r$

$$A = \frac{Mt^2}{\frac{\pi^2 \cdot d^8}{32^2} \cdot 2G} \cdot \int_0^{\frac{d}{2}} r^3 dr \int_0^{2\pi} d\varphi \cdot \int_0^{l} dy$$

$$A = \frac{32^2 \cdot Mt^2}{\pi^2 \cdot d^8 \cdot 2G} \cdot \frac{1}{4}\frac{d^4}{16} \cdot 2\pi \cdot l$$

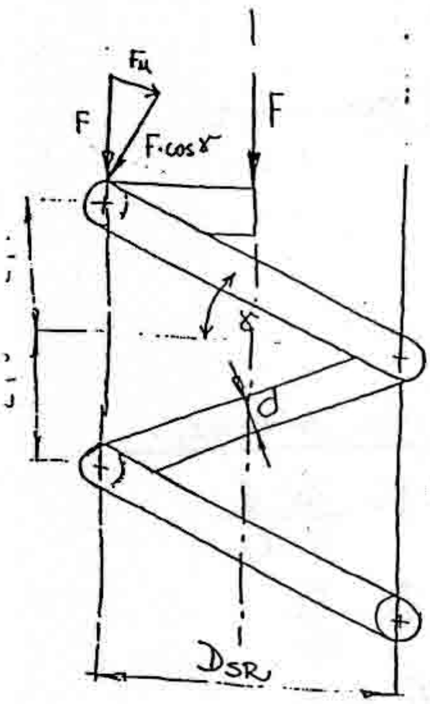
$A = 16 \cdot Mt^2 \cdot l$

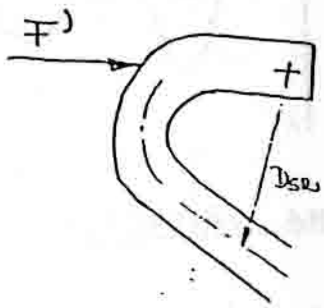
$$A_{max} = \frac{Mt^2 \cdot \frac{\pi d^2}{4} \cdot l}{\left(\frac{\pi \cdot d^3}{16}\right)^2 \cdot 2G}$$

$$A_{max} = \frac{32 \cdot Mt^2 \cdot l}{\pi \cdot d^4 \cdot G}$$

$$\eta = \frac{16 \cdot \cancel{Mt^2 \cdot l}}{\cancel{\pi \cdot d^4 G}} \cdot \frac{\cancel{\pi \cdot d^4 G}}{32 \cdot \cancel{Mt^2 \cdot l}}$$

$$\eta = \frac{16}{32} = \frac{1}{2}$$





1.) $M_t \doteq F \cdot \frac{D_{SR}}{2}$

$M_t = F \cdot \cos\gamma \cdot \frac{D_{SR}}{2}$

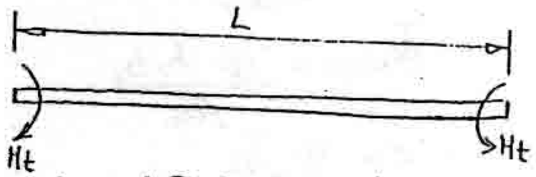
pri majhnih $\gamma \Rightarrow \cos\gamma \doteq 1$

$M_t = F \cdot \frac{D_{SR}}{2}$

$\tau_t = \frac{M_t}{W_p} = \frac{F \cdot D_{SR}}{0{,}2 \cdot d_1^3 \cdot 2}$

$\tau_t \leq \tau_{t\,dop}$

$\tau_{t\,dop} = \frac{\tau_D \cdot b_1 \cdot b_2}{\beta_k}$

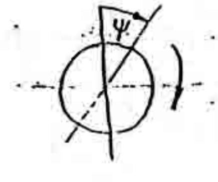


$L = i \cdot \pi \cdot D_{SR} \cdot \cos\gamma$

i - št. navojev vzmeti

2.) $\psi = \frac{M_t \cdot l}{G \cdot I_p} = \frac{F \cdot D_{SR} \cdot i \cdot \pi \cdot D_{SR}}{2 \cdot G \cdot \frac{\pi \cdot d^4}{32}}$

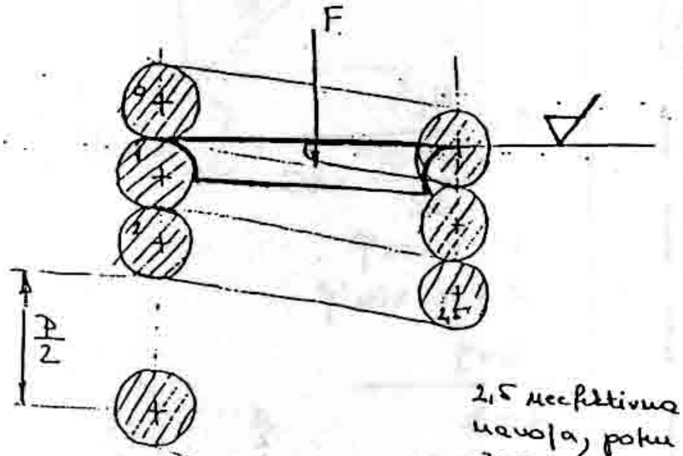
$$\psi = \frac{16 \cdot F \cdot D_{SR}^2 \cdot i_{ef}}{G \cdot d^4}$$



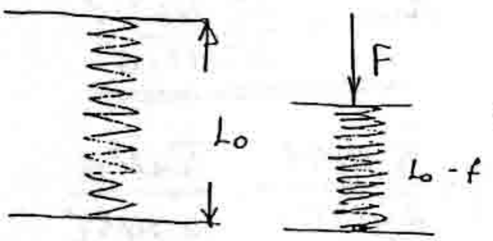
$f = \psi \cdot \frac{D_{SR}}{2}$

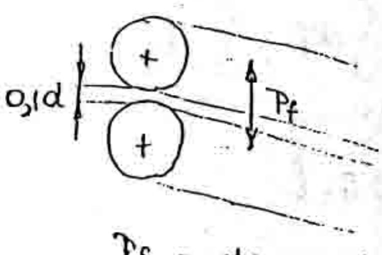
$$f = \frac{8 \cdot F \cdot D_{SR}^3 \cdot i_{ef}}{G \cdot d^4}$$

Kako zagotoviti centrično vnos sil?



2,5 neefektivna navoja, potem začnemo z efektivnim





$L_o \leq 2{,}65 \cdot D_{SR}$

$P_f = d + 0{,}1\, d$

$P = P_f + \frac{f}{i_{ef}}$

d-1T:

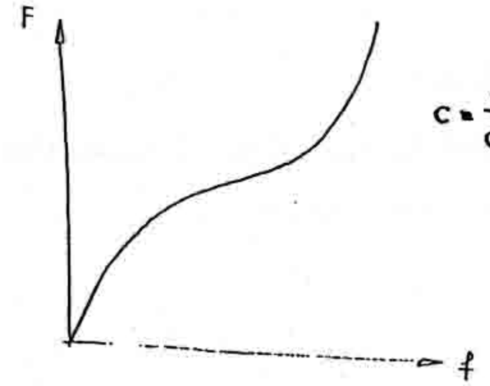
... se ⇒ ker se ne bo zvila kveč se bo izbočila (uklo...
in zato pri daljših vzmeteh obvezno vodenje.

$$c = \frac{F}{f}$$

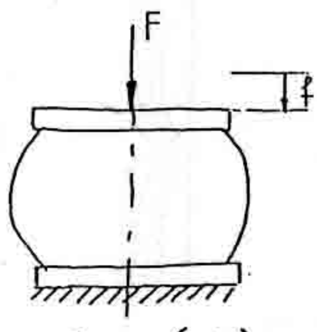
$$c = \frac{\cancel{F} \cdot G \cdot d^4}{8 \cdot \cancel{F} \cdot D_{sr}^3 \cdot i_{ef}}$$

$$\boxed{c = \frac{G \cdot d^4}{8 \cdot D_{sr}^3 \cdot i_{ef}}}$$

* GUMIJASTE VZMETI:



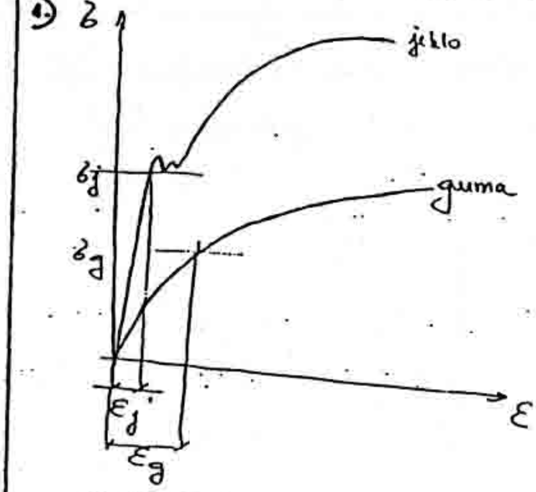
$$c = \frac{dF}{df}$$

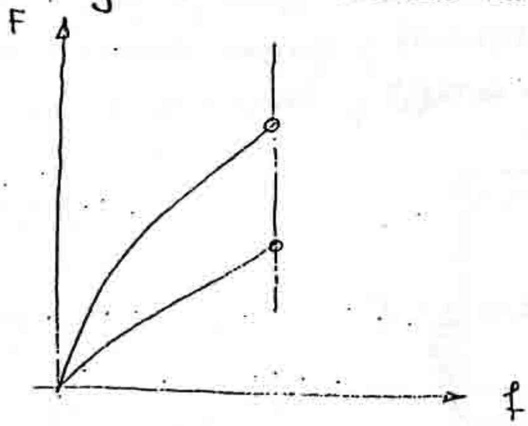


$c = c(sh)$

karakteristiko vzmeti spreminjam z kvaliteto materiala

1.)

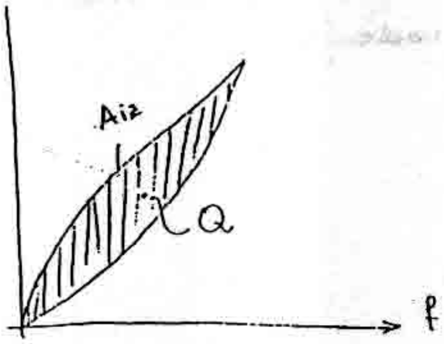


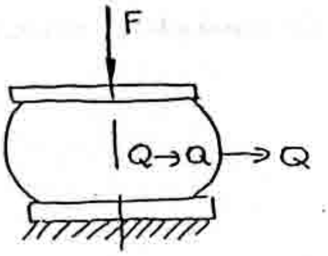


$c \propto E, G$

$E, G = f(sh)$

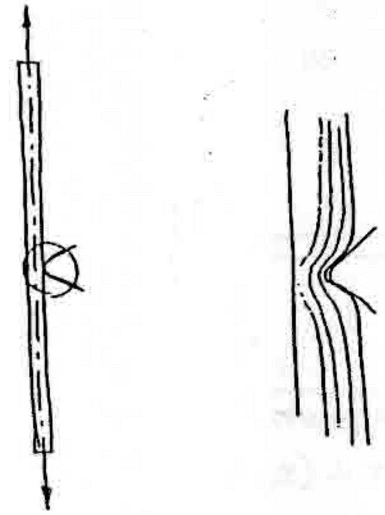
2.)





Posledica Q:

- drugačno karakteristiko
- staranje
- guma ni za visokodinamična obremenitva (ni časa za odvod toplote v okolico)



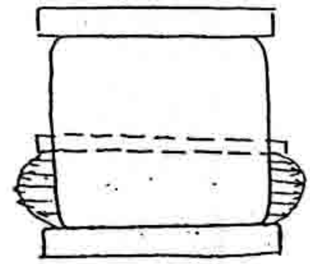
$\alpha_K = f$ (oblike)

guma je 100% občutljiva na zareze

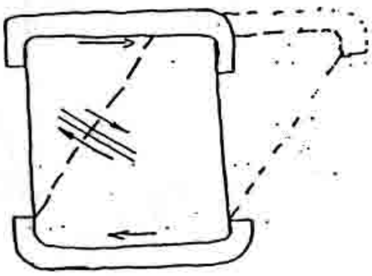
η_K – izredno velik

Osnovna obremenitev gume je tlak. Če hočemo, da guma opravlja funkcijo vzmeti, potem moramo pustiti da iztisnjen volumen neovirano teče (a), lahko prenaša tudi strig v plasteh (b)

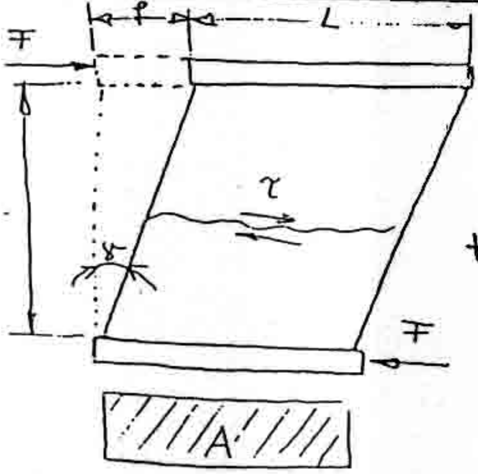
a)



b)



PRIZMATIČNA STRIŽNA GUMIJASTA VZMET:



$$\tau = \frac{F}{A} = \gamma \cdot G$$

$$\gamma = \frac{\tau}{G}$$

$$\tau \leq \tau_{dop}$$

$$\operatorname{tg}\gamma \approx \gamma \Rightarrow f = \gamma \cdot h = \frac{\tau}{G} \cdot h$$

$$f = \frac{F \cdot h}{A \cdot G}$$

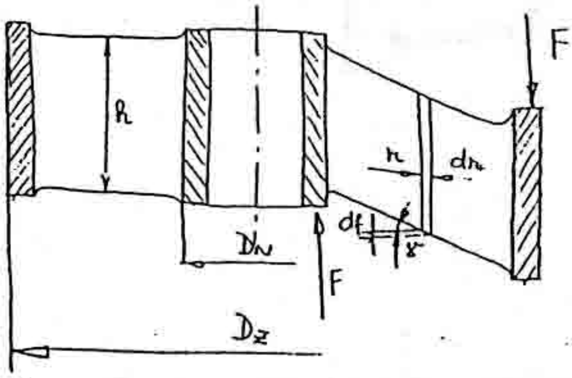
$$c = \frac{F}{f} = \frac{A \cdot G}{h}$$

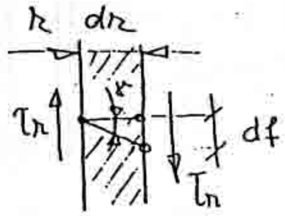
(ni treba izpeljat)

$\eta_V = 1$

$\tau_{dop} = f$(trdota gume, vrsta gume)

DIMENZIONIRANJA TER IZKORISTEK VZMETI





$$f = \int_{R_N}^{R_Z} df$$

$$df = \gamma \cdot dr$$

$$\gamma = \frac{F}{A \cdot G}$$

$$\gamma = \frac{F}{G} \cdot \frac{1}{2\pi r h}$$

$$f = \frac{F}{2\pi h G} \cdot \int_{R_N}^{R_Z} \frac{dr}{r}$$

$$f = \frac{F}{2\pi h G} \cdot \ln \frac{R_Z}{R_N}$$

$$c = \frac{F}{f} = \frac{2\pi h G}{\ln \frac{R_Z}{R_N}}$$

$$\tau_r = \frac{F}{2\pi r h}$$

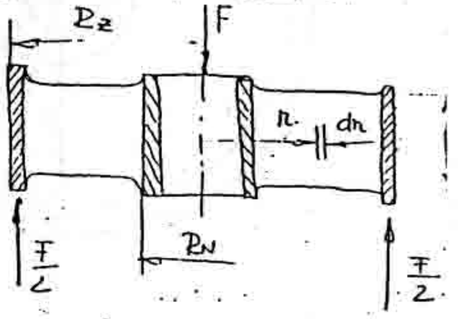
$$\tau_{max} = \frac{F}{2\pi R_N h}$$

$$\tau_{max} \leq \tau_{dop}$$

$\tau_{dop} = f$ (sh) vrsta din. obrem

$$\eta_V = \frac{\int_V \frac{\tau^2}{2G} \cdot dV}{\frac{\tau_{max}^2}{2G} \cdot V} = \frac{A}{A_{max}}$$

IZKORISTEK VZMETI



$$A = \frac{1}{2G} \cdot \int \left(\frac{F}{2\pi r h} \right)^2 dV$$

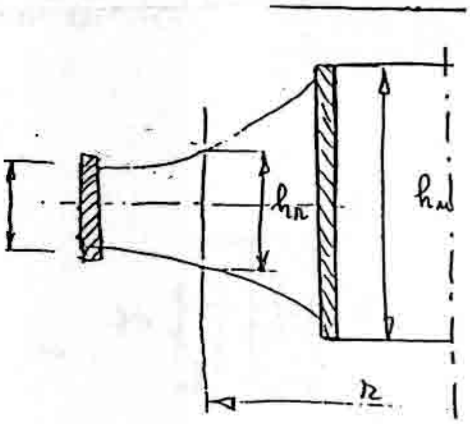
$$A = \frac{1}{2G} \cdot \frac{F^2}{4\pi^2 h^2} \cdot \int_V \frac{1}{r^2} \cdot J \cdot d_2 d_1$$

$$A = \frac{F^2}{4G\pi \cdot h} \cdot \ln \frac{R_Z}{R_N}$$

$$A_{max} = \left(\frac{F}{2\pi R_N \cdot h} \right)^2 \cdot \frac{\pi \cdot h (R_Z^2 - R_N^2)}{2G}$$

$$A_{max} = \frac{F^2 (R_Z^2 - R_N^2)}{8 \cdot \pi \cdot h \cdot R_N^2 G}$$

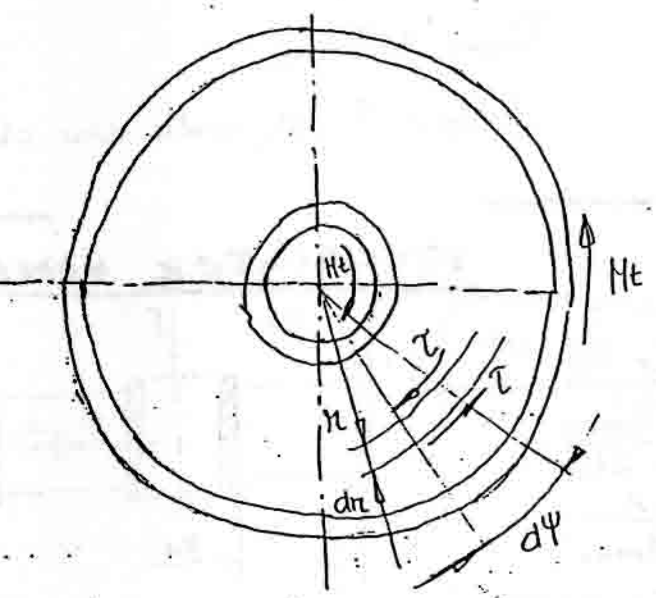
$$\eta_V = \frac{2 \cdot R_N^2}{(R_Z^2 - R_N^2)} \cdot \ln \frac{R_Z}{R_N}$$

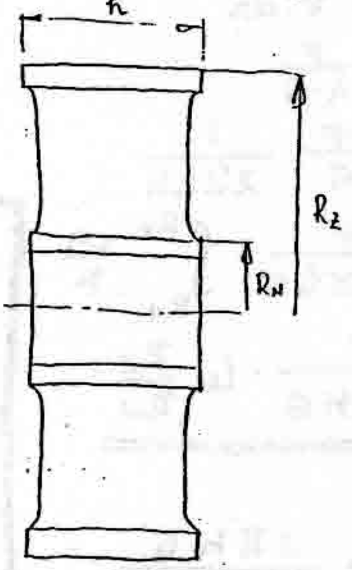


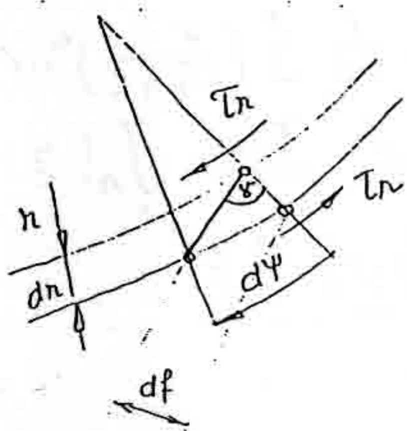
$h(r) = f(r)$

$$\left.\begin{aligned}\frac{h_N}{h_z} = \frac{R_N}{R_z} \\ \tau = konst\end{aligned}\right\} \Rightarrow \eta_v = 1$$

) ZA KOLUTNO TORZIJSKO STRIŽNO GUMIJASTO VZMET DOLOČI PRAVILO ZA VEČANJE VIŠINE, ČE JE VZMET OBLIKOVANA KOT TELO ENAKIH STRIŽNIH NAPETOSTI. KOLIK JE ZASUK IN KOLIK IZKORISTEK?







$$\tau_r = \frac{Mt}{2\pi r^2 h}$$

$$\tau_{max} = \frac{Mt}{2\pi R_N^2 \cdot h}$$

$$\tau_{max} \leq \tau_{dop}$$

$$df = \frac{F \cdot dr}{G \cdot A} = \frac{Mt \cdot dr}{2\pi r^2 \cdot h \cdot G} = r \cdot d\psi$$

$$d\psi = \frac{Mt \cdot dr}{2\pi r^3 \cdot h \cdot G}$$

$$\psi = \int_{R_N}^{R_z} \frac{Mt}{2\pi h G} \cdot \frac{dr}{r^3}$$

$Mt \quad [1 \quad 1]$

$$c = \frac{Mt}{\varphi} = \frac{Mt}{\frac{Mt}{4G\pi \cdot h} \cdot \left[\frac{1}{R_N^2} - \frac{1}{R_z^2}\right]}$$

$$c = \frac{4G\pi \cdot h}{\left[\frac{1}{R_N^2} - \frac{1}{R_z^2}\right]}$$

$$\gamma_{max} = \frac{Mt}{2\pi h R_N^2}$$

PRAVILO ZA VEČANJE VIŠINE:

$$\tau_s = konst \leq \tau_{s\,dop}$$

$$\tau_s = \gamma \cdot G = \frac{F}{2\pi r h} = \frac{Mt}{2\pi r^2 h}$$

$$Mt = \tau_{s\,dop} \cdot 2\pi r^2 \cdot h$$

$$h = \frac{Mt}{\tau_{s\,dop} \cdot 2\pi \cdot r^2}$$

IZKORISTEK VZMETI:

$$\eta_v = \frac{\int_V \frac{\tau^2}{2G} \cdot dV}{\frac{\tau_{max}^2}{2G} \cdot V} = \frac{A}{A_{max}}$$

$$A = \frac{1}{2G} \cdot \int \frac{Mt^2}{4\pi^2 h^2 r^4} \cdot 2\pi r h \, dr$$

$$A = \frac{1}{2G} \cdot \frac{Mt^2}{4\pi h^2} \cdot 2\pi h \cdot \int_{R_N}^{R_z} \frac{dr}{r^3}$$

$$A = \frac{Mt^2}{8 \cdot G \cdot \pi \cdot h} \cdot \left[\frac{1}{R_N^2} - \frac{1}{R_z^2}\right]$$

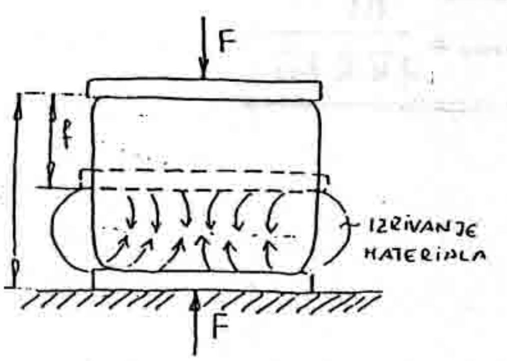
$$A = \frac{Mt^2}{8 \cdot G\pi \cdot h} \cdot \frac{(R_z^2 - R_N^2)}{R_N^2 R_z^2}$$

$$A_{max} = \frac{1}{2G} \cdot \frac{Mt^2}{4\pi^2 h^2 \cdot R_N^4} \cdot (R_z^2 - R_N^2)\pi \cdot h$$

$$A_{max} = \frac{Mt^2}{8 \cdot G\pi h} \cdot \frac{(R_z^2 - R_N^2)}{R_N^4}$$

$$\eta_v = \frac{\cancel{Mt^2}}{\cancel{8 \cdot G \cdot \pi \cdot h}} \cdot \frac{\cancel{(R_z^2 - R_N^2)}}{R_N^2 R_z^2} \cdot \frac{\cancel{8G\pi h} \ldots}{\cancel{Mt^2} \cancel{(R_z^2 \ldots}}$$

$$\eta_v = \frac{R_N^2}{R_z^2}$$



$$\sigma_{TL} = \frac{F}{A}$$

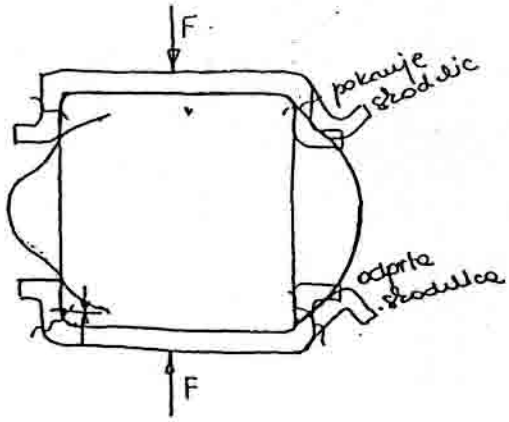
$$\sigma_{TL} \leq \sigma_{TL\,dop}$$

$$\sigma_{TL\,dop} = f(sh, dim.)$$

$$f = h \cdot \varepsilon = h \cdot \frac{\sigma}{E}$$

$$c = \frac{A \cdot E}{h}$$

$$c = c(\text{dimenzij}, E(sh, K))$$



$$E = E(sh, K)$$

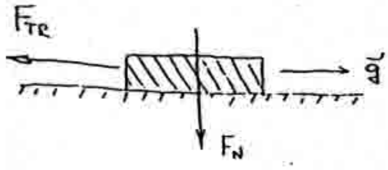
$$K = \frac{\text{prosta površina gume}}{\text{vpeta površina gume}}$$

LEŽAJI:

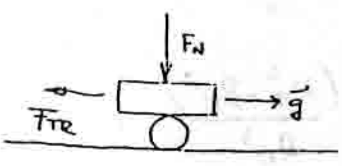
Ležaji:
- drsni
- kotalni

TRENJE:

drsno trenje:



b) kotalno trenje:



$$\boxed{P = V \cdot X \cdot F_R + Y \cdot F_A}$$

TOZO: $V = 1$

TUNO: $V = 1{,}2$

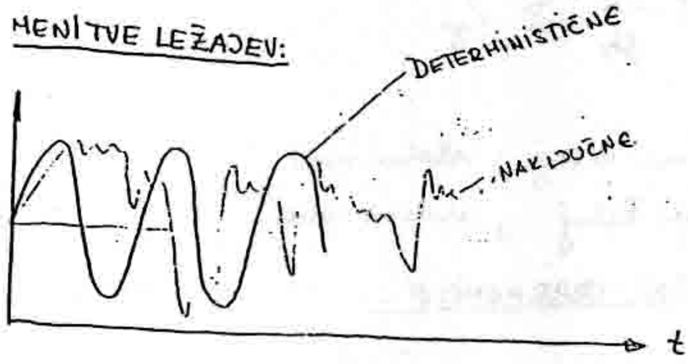
$$(X, Y) \to f\left(\frac{F_A}{V \cdot F_R}\right)$$

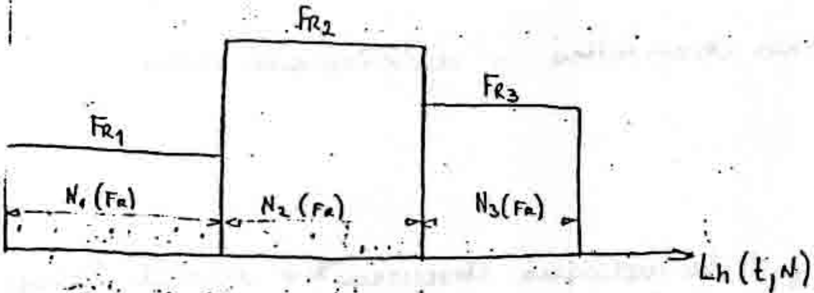
- faktor vrtljivosti in vrste obremenitve

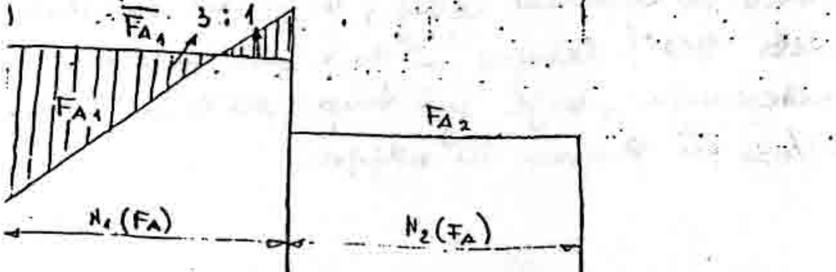
$$\left(\frac{P}{C}\right)^3 = \frac{10^6}{n}$$

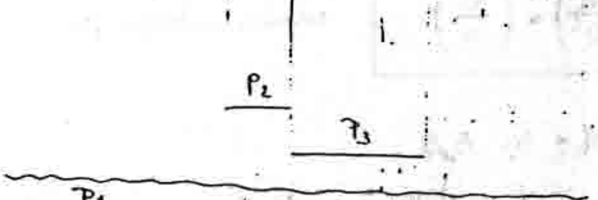
$n =$

MENITVE LEŽAJEV:

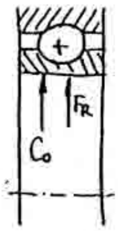




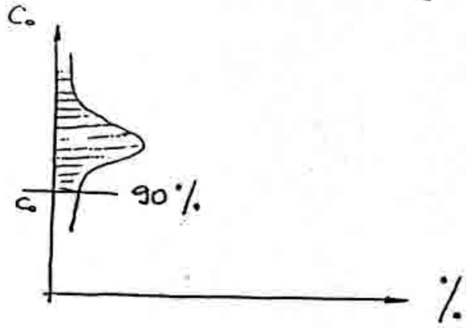




P - ekvivalentni



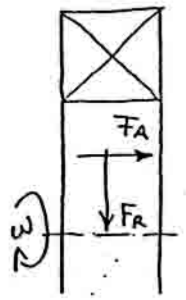
C_0 - statična nosilnost: je tista radialna obremenitev za rad. ležaje, oziroma aksialna obremenitev za aksialne ležaje, ki jo prenese 90% ležajev in ki povzroči kritično deformacijo kotalnega elementa ki je 0,01 % premera kotalnega elementa



$$f_s = \frac{C_0}{P} \qquad S_0 = \frac{C_0}{P_0} \geq f_s$$

$f_s < 1$; močno obremenjen ležaj, slabo vodi
$f_s > 1$; malo obremenjen ležaj, dobro vodi

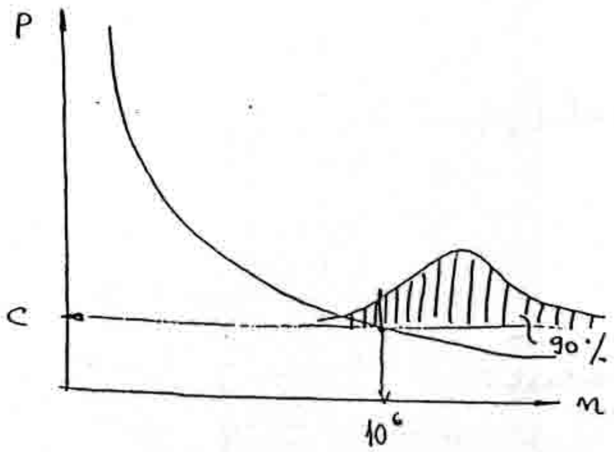
II. DIMENZIONIRANJE PRI DINAMIČNI OBREMENITVI:



$\omega \to n_L \to L_h(\omega)$

n - število sprememb obremenitev v določenem času

C - dinamična nosilnost je tista radialna obremenitev za rad. ležaj in tiste aksialna obremenitev za aksialen ležaj, ki jo do začetka luščenja površine zadrži 90% ležajev in to v preskusnih idealnih pogojih obratovanja, to je pri temp. 20°C in pri vrtilni hitrosti 33,3 vrt/min in skupno 10^6 vrtljajev.



$$\boxed{\left(\frac{n}{10^6}\right) = \left(\frac{C}{P}\right)^{\varkappa}}$$ zakon utrujanja

$\varkappa = 3;\ 3,3$

↓ kroglične ležaje

↓ valjčne ležaje

$$\left(\frac{P}{C}\right)^{\alpha} = \frac{10^6}{n}$$

α $\alpha = 3$

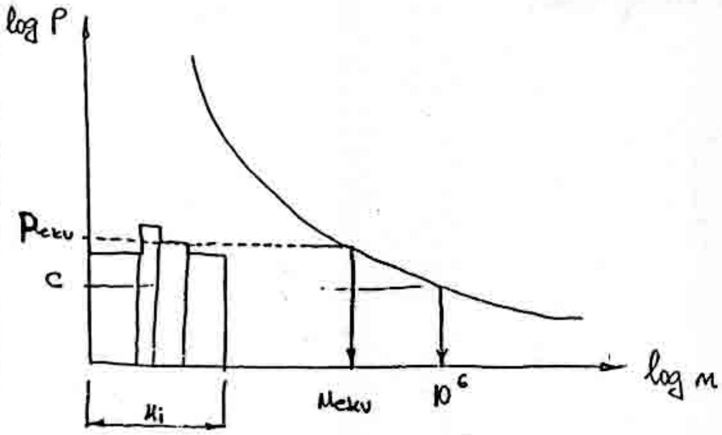
$$P^3 \cdot n = C^3 \cdot 10^6$$

trajanje obremenitve

velikost obremenitve

$$P_{ekv}^3 \cdot \sum_{i=1}^{4} (n_i) = P_1^3 \cdot n_1 + P_2^3 \cdot n_2 + \ldots + P_4^3 \cdot n_4$$

$P_{ekv} =$

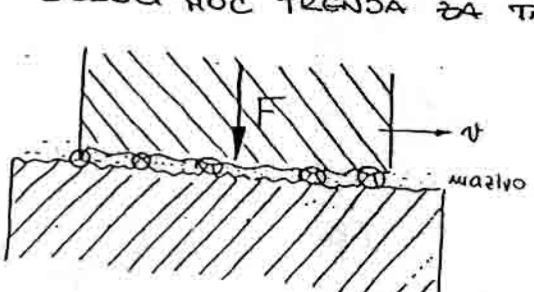


$$\left(\frac{P_{ekv}}{C}\right)^3 = \frac{10^6}{n_{ekv}}$$

$n_{ekv} =$

II DRSNI LEŽAJI:

* 33) RAZLOŽI SUHO TRENJE, NAČIN DIMENZIONIRANJA RADIALNEGA LEŽAJA IN DOLOČI MOČ TRENJA ZA TA PRIMER.

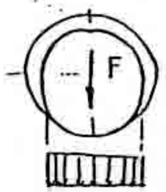


Rt - velik

F - velik

- obraba
- visoki specifični tlaki

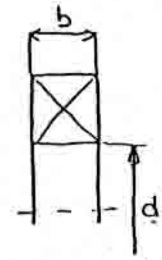
NAČIN DIMENZIONIRANJA:

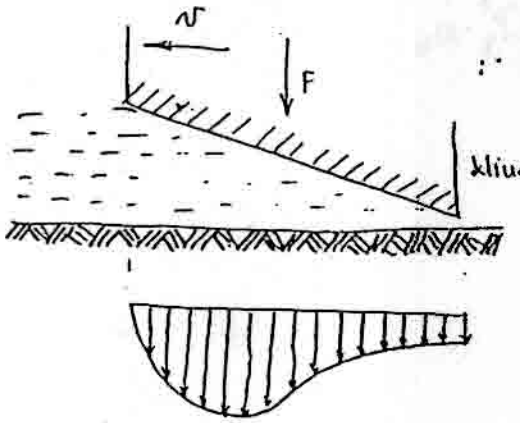


$$p = \frac{F}{b \cdot d}$$

$$p < p_{dop}$$

$p_{dop} = p_{dop}$(mehkejšega materiala)





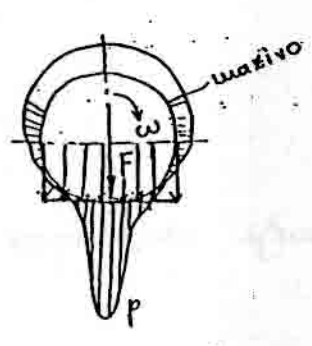
klinast medprostor

MOČ TRENJA:

$$\boxed{P_{tr} = F \cdot \mu_g \cdot v}$$

Moč trenja se lokalno spreminja v toplotni tok

39) RAZLOŽI MEŠANO TRENJE IN NAČIN DIMENZIONIRANJA LEŽAJEV V TAKEM PRIMERU, MOČ TRENJA.



mešano trenje:
- veliki pritiski
- mirovanje
- nepreintenzivno drsenje
- obraba na točkah, konicah se

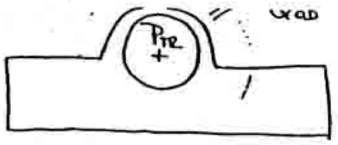
MOČ TRENJA:

$$P_{tr} = F \cdot \mu \cdot v$$

$$P_{tr} = p \cdot d \cdot b \cdot \mu \cdot v$$

$$\frac{P_{tr}}{d \cdot b \cdot \mu} = \overbrace{p \cdot v}^{\text{tipični parametri za obratovalne pogoje}}$$

$$(p \cdot v) \leq (p \cdot v)_{mejni}$$



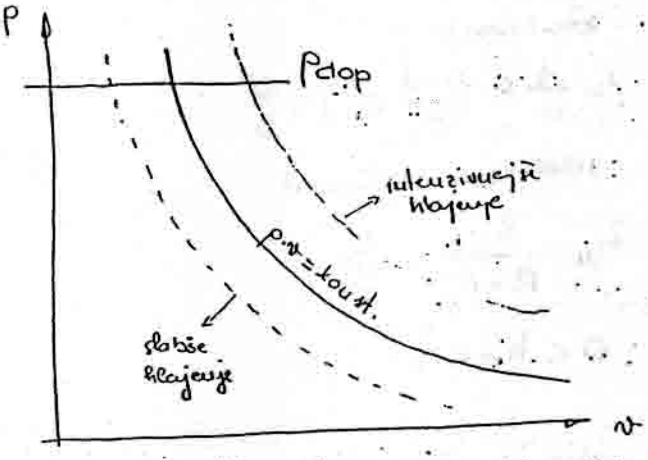
a dano pogoj: $P_{tr} = Q$

$Q = \alpha \cdot A \cdot \Delta\vartheta$

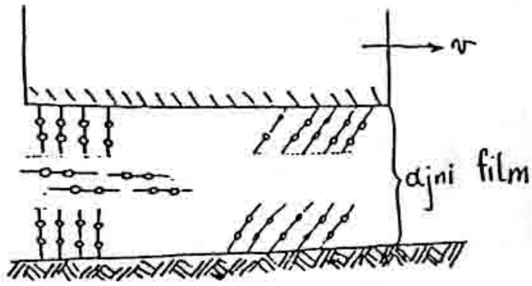
$\alpha \cdot A \cdot \Delta\vartheta = \mu \cdot p \cdot d b \cdot v$

$$\boxed{p \cdot v = \frac{\alpha \cdot A \cdot \Delta\vartheta}{\mu \cdot d \cdot b}}$$

$(p \cdot v) \leq (p \cdot v)_{mejni}$



TEKOČINSKO TRENJE:



Lastnosti maziva:

- dolge verižaste molekule
- sposobnost prijetja na kovino

$\tau = \eta \cdot \frac{dv}{dy} = \frac{F_{tr}}{A} = \frac{\mu \cdot F_r}{b \cdot d}$

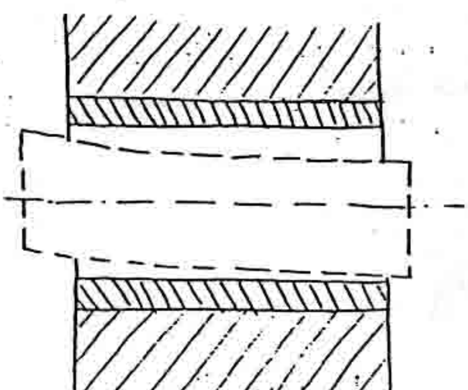
$\mu = 0{,}01 \div 0{,}05$

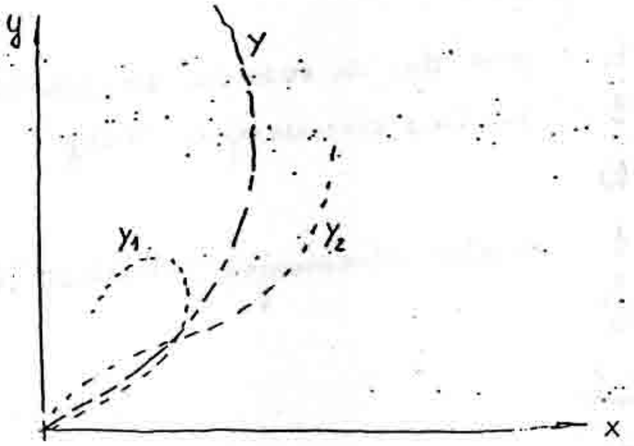
$\tau < \tau_{dop}$ (f mazanja, hlap. mat.)

η - dinamična viskoznost [cSt]

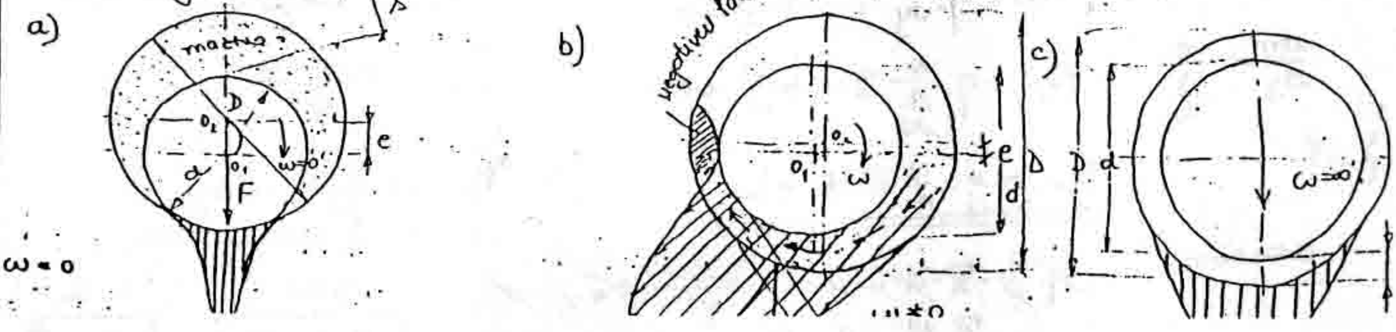
STREBECKOVA KRIVULJA:

* 36.) SKICIRAJ POT POTOVANJA ČEPA DRSNEGA LEŽAJA PRI VEČANJU KOTNE HITROSTI TER PORAZDELITEV TLAKA V OLJNEM FILMU PRI DOLOČENI KOTNI HITROSTI





POTOVANJE ČEPA:



- zračnost

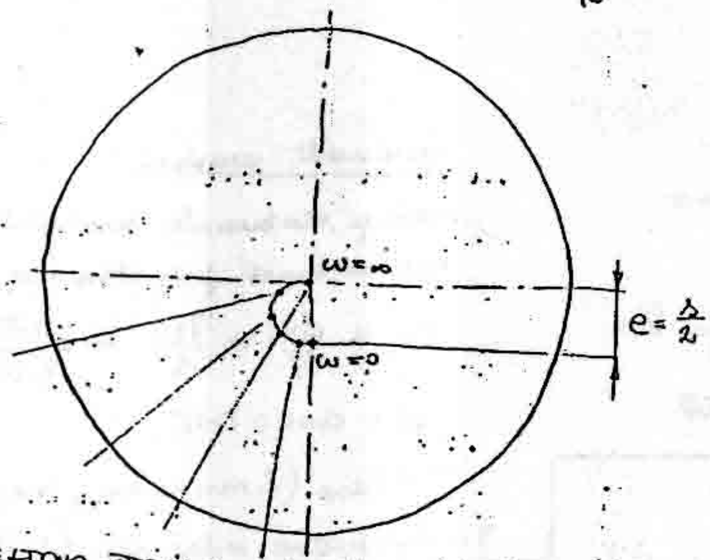
$$\psi = \frac{\Delta}{d} = \frac{D-d}{D} = 1 - \frac{d}{D}$$

- relativna zračnost

$$h_R = \frac{h_o}{R-r} = \frac{h_o}{\frac{\Delta}{2}}$$

$$0 < h_r < 1$$

Selјenje čepa glede na središče lukuje



SOMMERFELDOVO ŠTEVILO:

$$\boxed{S_o = \frac{p \cdot \psi^2}{\eta \cdot \omega}}$$

$S_o = 1$ pove da so razmere za tekočinsko trenje normalne

$S_o > 1$ močno obremenjeni ležaj

$S_o \to 10$

$S_o < 1$ malo obremenjen, hitrotekoč ležaj

$S_o \to \frac{1}{10}$

$i ; S_o < 1$

$$P_{tr} = \tau_s \cdot \pi \cdot d \cdot b \cdot \frac{d}{2} \cdot \omega = \eta \cdot \frac{dv}{dy} \cdot \pi \cdot d \cdot b \cdot \frac{d}{2} \cdot \omega$$

$$\frac{dv}{dy} = \frac{v}{\frac{\Delta}{2}} \qquad P_{tr} = \eta \cdot \frac{v}{\frac{\Delta}{\cancel{2}}} \cdot \pi \cdot d \cdot b \cdot \frac{d}{\cancel{2}} \cdot \omega$$

$$\frac{\Delta}{d} = \psi$$

$$\underline{\underline{P_{tr} = \eta \cdot \frac{v}{\Delta} \pi d^2 b \omega}}$$

$$P_{tr} = F_{tr} \cdot v$$

$$P_{tr} = p \cdot d \cdot b \cdot \mu \cdot v$$

$$p = \frac{S_o \cdot \eta \cdot \omega}{\psi^2}$$

$$\underline{\underline{P_{tr} = \frac{S_o \eta \cdot \omega}{\psi^2} \cdot d \cdot b \cdot \mu \cdot v}}$$

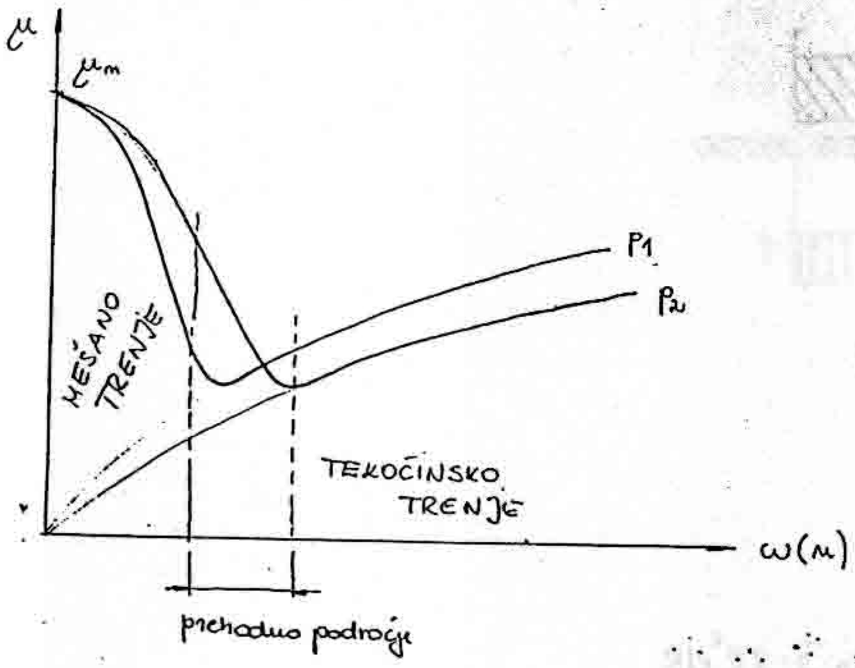
IZENAČIM:

$$\cancel{\eta} \cdot \frac{1}{\cancel{\psi}} \cdot \pi \cdot \cancel{d} \cdot \cancel{b} \cdot \cancel{\omega v} = \frac{S_o \cancel{\eta} \cancel{\omega}}{\psi^{\cancel{2}}} \cancel{d} \cancel{b} \mu \cdot \cancel{v}$$

$$\pi \cdot \psi = S_o \cdot \mu$$

$S_o < 1$ $\boxed{\frac{\mu}{\psi} = \frac{\pi}{S_o}}$

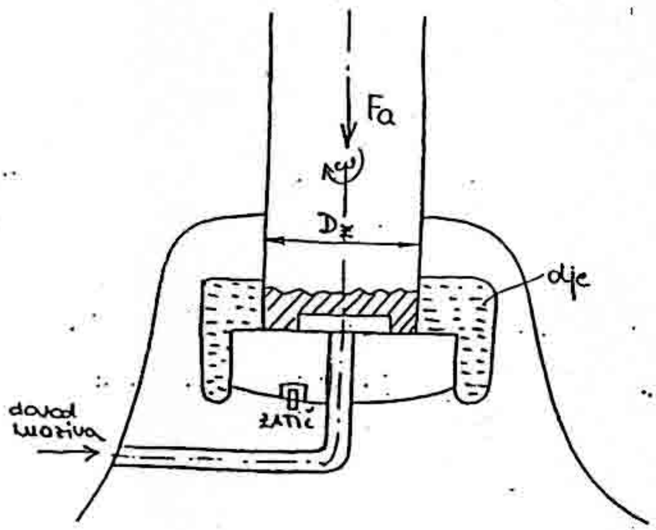
$S_o > 1$ $\boxed{\frac{\mu}{\psi} = \frac{\pi}{\ }}$



$P_2 > P_1$ – špranja manjš

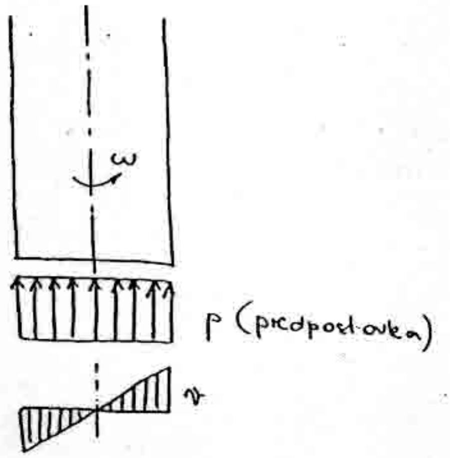
AKSIALNI LEŽAJ:

* 44.) SKICIRAJ AKSIALNI DRSNI LEŽAJ IN DOLOČI MOMENT TRENJA IN SREDNJI TORNI POLMER.

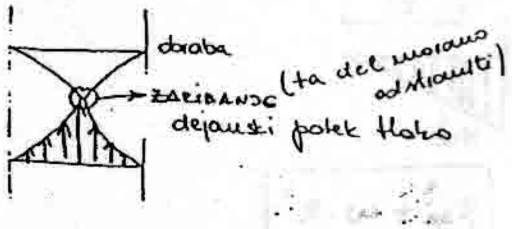


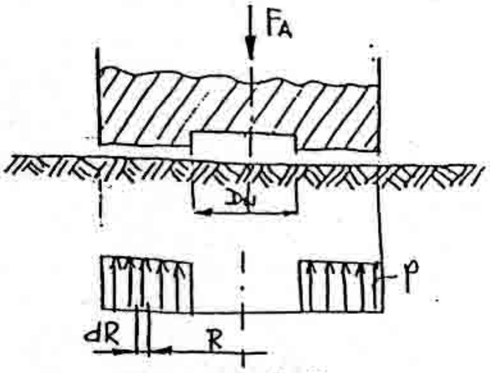
$$p = \frac{F_a}{\frac{\pi}{4} \cdot D_z^2}$$

$$p \leq p_{dop}$$



*↓





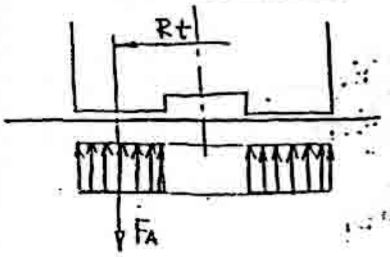
$$p = \frac{F_A}{\frac{\pi}{4}\cdot\left(D_z^2 - D_N^2\right)}$$

$$dM_{tr} = p\cdot\mu_g\cdot\pi\, 2R^2\, dR$$

$$M_{tr} = \int_{R_N}^{R_z} \frac{F_A}{\frac{\pi}{4}\cdot\left(D_z^2 - D_N^2\right)}\cdot\mu_g\cdot\pi\cdot 2R^2\, dR$$

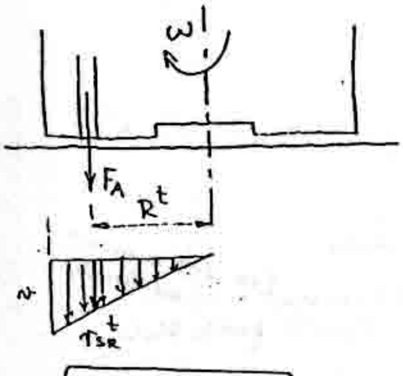
$$\boxed{M_{tr} = \frac{2\cdot F_A\cdot\mu_g}{R_z^2 - R_N^2}\cdot\frac{R_z^3 - R_N^3}{3}}$$

SREDNJI TORNI POLMER:

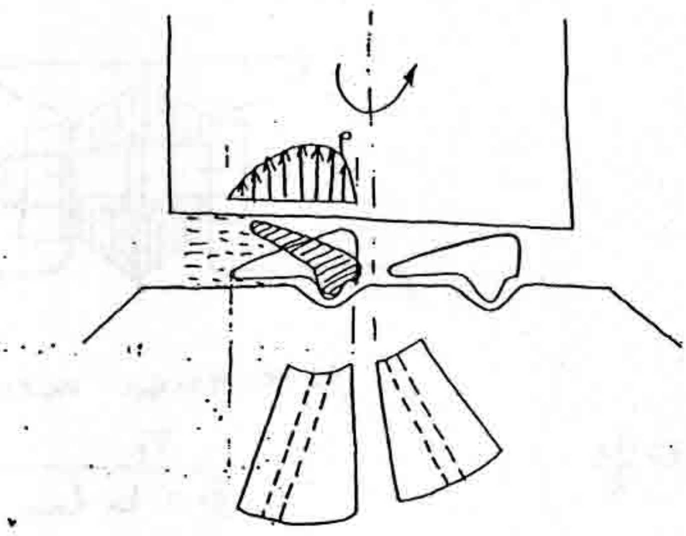


$$M_{tR} = F_A\cdot\mu\cdot R^t$$

$$\boxed{R^t = \frac{2}{3}\left[\frac{R_z^3 - R_N^3}{R_z^2 - R_N^2}\right]}$$



$$\boxed{v_{sR}^t = \omega\cdot R^t}$$



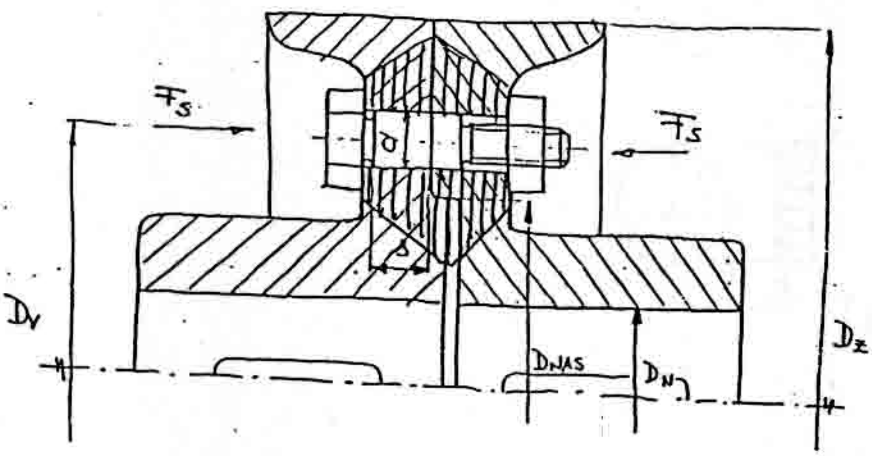
SKLOPKE

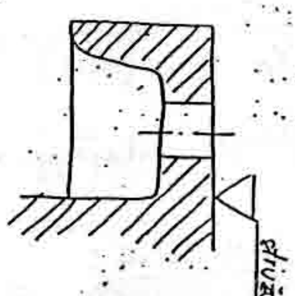
I. TOGE SKLOPKE ZA STALNO ZVEZO

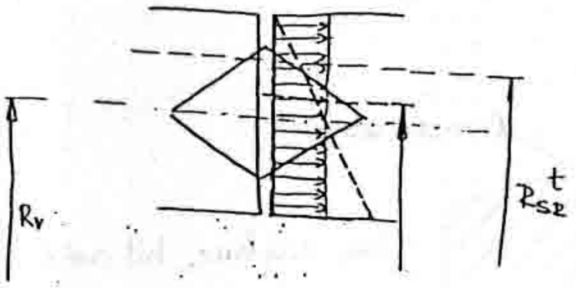
* 52.) SKICIRAJ KOLUTNO SKLOPKO S PRILAGODNIMI VIJAKI ZA HITROST NAD $20\ \frac{m}{s}$ IN DOLOČI PRERAČUN SKLOPKE. SKLOPKA IMA CENTRIRNI NASE

$v \leq 20\ \frac{m}{s}$ lite izvedba

$v \geq 20\ \frac{m}{s}$; stružena izvedba.





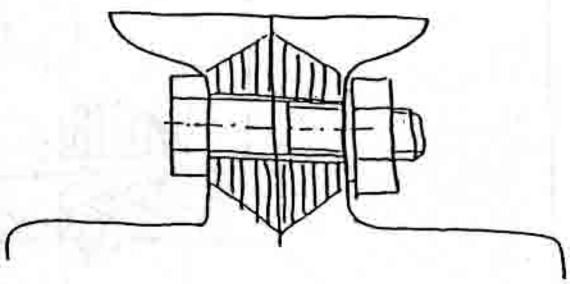


z R_{sr}^t računam, či imam enakomerno porazdelitev tlaka

$$M_{t\,max} \leq n \cdot F_s \cdot R_{se}^{t} \cdot \mu_{d}$$

$$R_{se}^{t} = \frac{2}{3}\,\frac{R_z^3 - R_N^3}{R_z^2 - R_N^2}$$

$$R_{se}^{t} \neq R_v$$



1) KONTROLA VIJAKA

$$M_{KLJ} = F_s \cdot tg(\alpha + \rho') \cdot \frac{d_2}{2} + \mu_A F_s \frac{d_A}{2}$$

$$\sigma = \frac{F_s}{\frac{\pi d_1^2}{4}}$$

$$\tau = \frac{F_s \cdot tg(\alpha+\rho') \cdot \frac{d_2}{2}}{W_p}$$

$$\sigma_p = \sqrt{\sigma^2 + 3\tau_t^2}$$

$$\sigma_p \leq \sigma_{dop}$$

$$\sigma_{dop} = 0{,}6 \cdot \sigma_v$$

2) KONTROLA MOZNIKA

$$\tau = \frac{F_t}{\frac{2}{3} \cdot i \cdot b \cdot l_{nd}}$$

$$\tau < \tau_{dop}$$

$$F_t = \frac{2M_t}{D_N}$$

$$p = \frac{F_t}{\frac{2}{3} i \cdot \frac{h}{2} \cdot l_{nd}}$$

$$p \leq p_{dop}$$

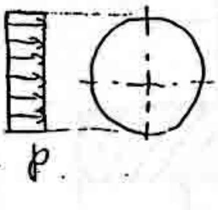
$p_{dop} = f$(mehkejšega materiala)

b) PRILAGODNI VIJAK (glej sliko)

$$M_{t\,max} = \frac{2}{3} \cdot n \cdot \tau_s \cdot A_v \cdot R_v$$

$\tau_s \leq \tau_{s\,dop}$ (za vijak)

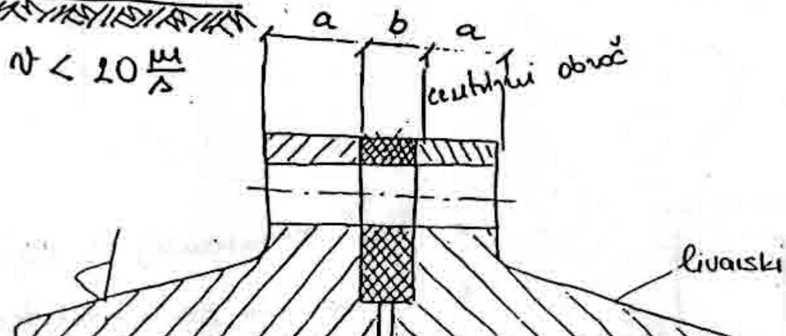
$$p = \frac{M_{t\,max}}{R_v \cdot \frac{2}{3} n\,(d \cdot s)}$$



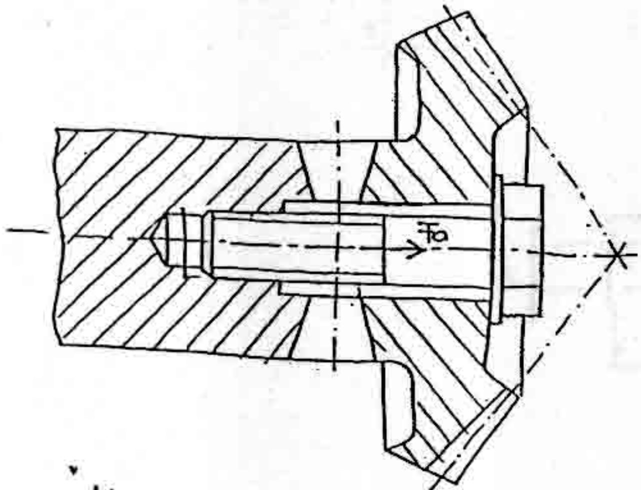
$p \leq p_{dop}$(mehkejšega mat.)

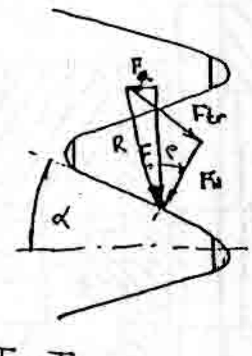
LITA IZVEDBA:

za $v < 20 \frac{m}{s}$



za majhne hitrosti zaradi odrečnih mas.





$$F = \frac{2M_t}{D}$$

$$F_a = F \cdot tg(\alpha - \rho')$$

$$M_{kq} = F_v \cdot tg(\alpha + \rho') \cdot \frac{d_2}{2} + F_v \cdot \mu_A \cdot \frac{d_A}{2}$$

$$\tau_t = \frac{M_t}{W_p}$$

$$\sigma_p = \sqrt{(\sigma_v + \sigma_s)^2 + 3\tau_t^2}$$

$$\sigma_v = \frac{F_v}{\frac{\pi d_1^2}{4}}$$

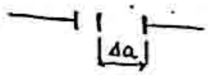
$$\sigma_p \leq \sigma_{dop}$$

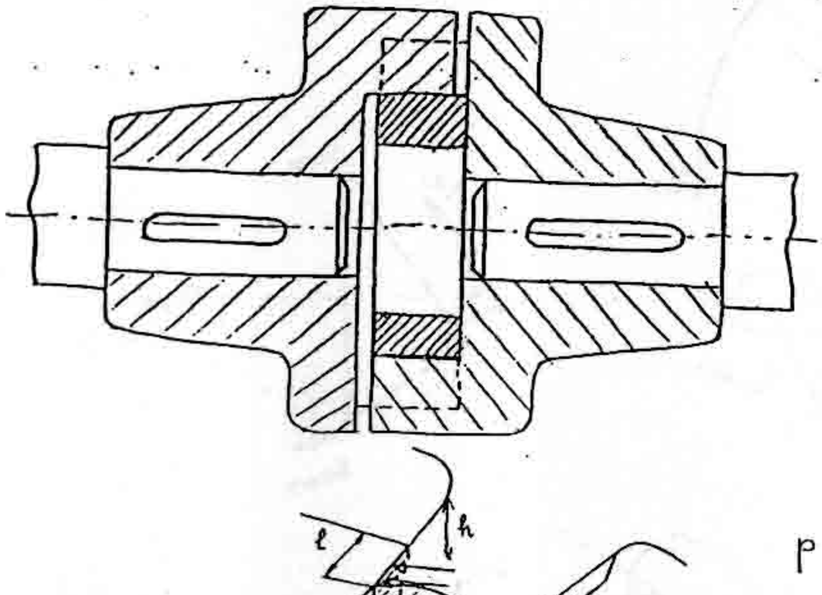
$$\sigma_s = \frac{F_a}{\frac{\pi d_1^2}{4}}$$

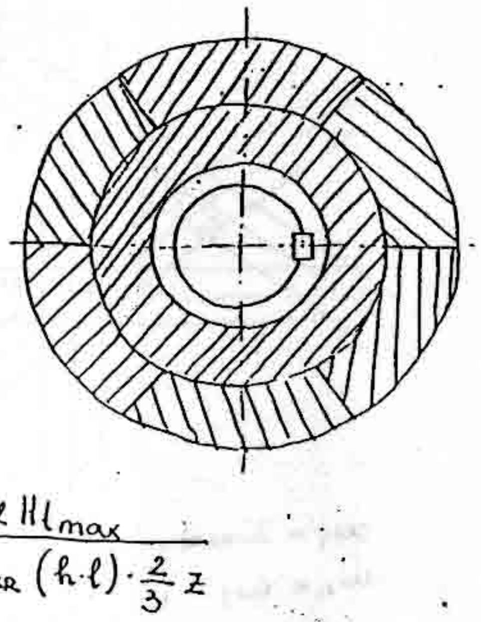
$$\underline{\underline{\sigma_{dop} = 0{,}6 \cdot \sigma_y}}$$

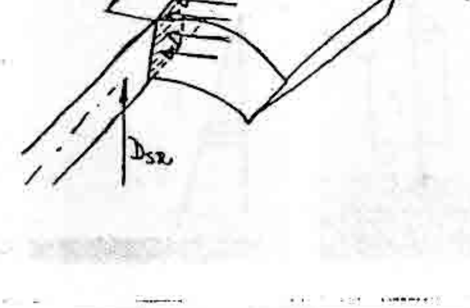
II. IZRAVNALNE SKLOPKE:

* PARKLASTA SKLJOPKA:



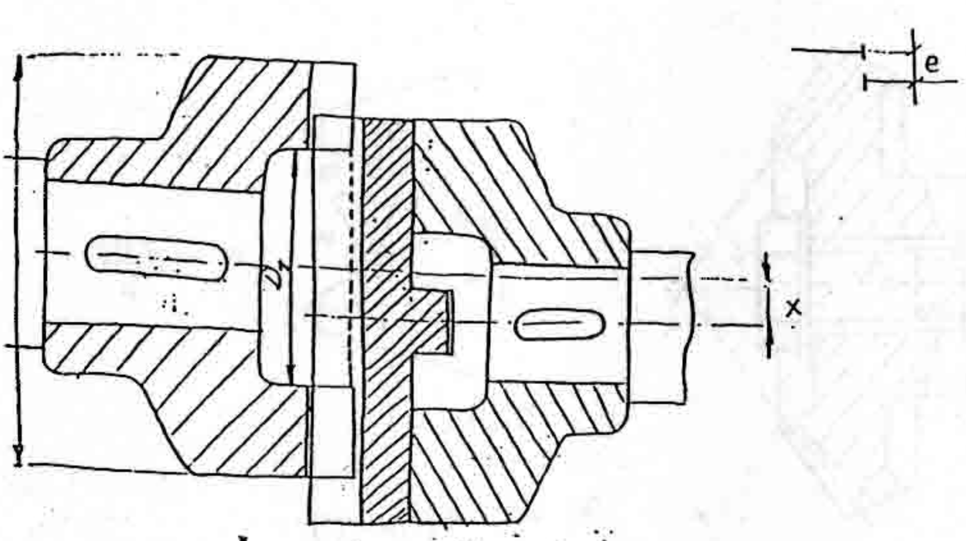


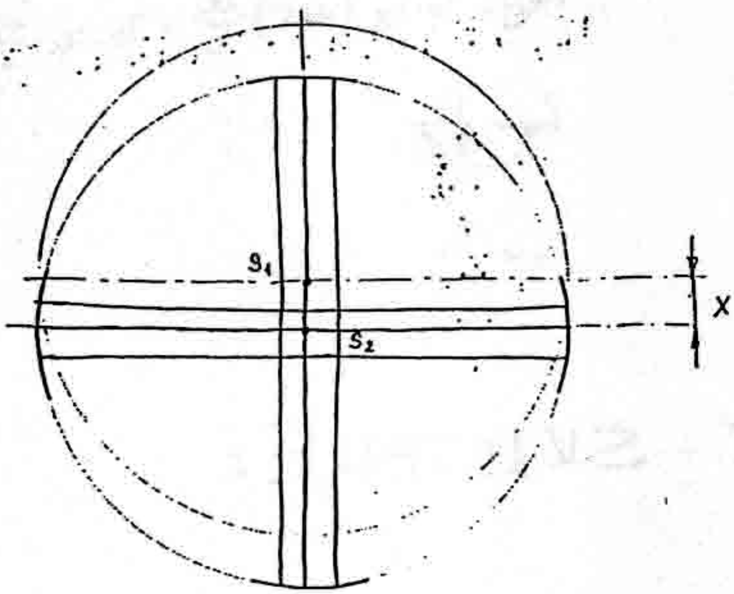


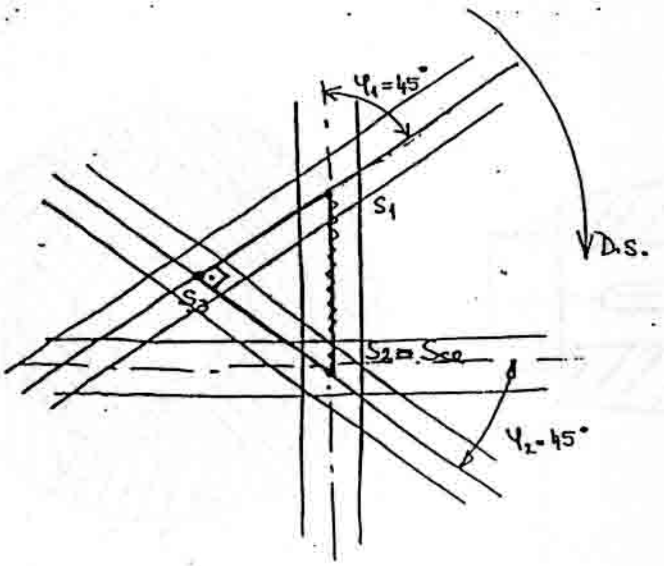


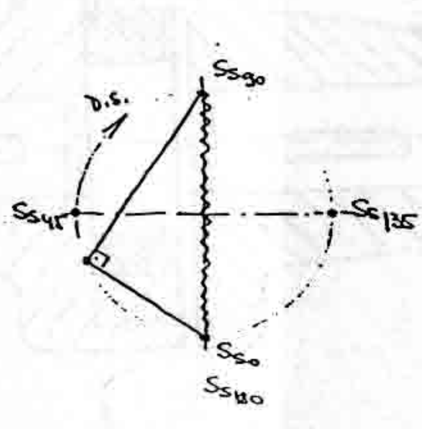
$$p = \frac{2M_{t\,max}}{D_{sr}(h \cdot l) \cdot \frac{2}{3} z}$$

$$p \leq p_{dop}$$







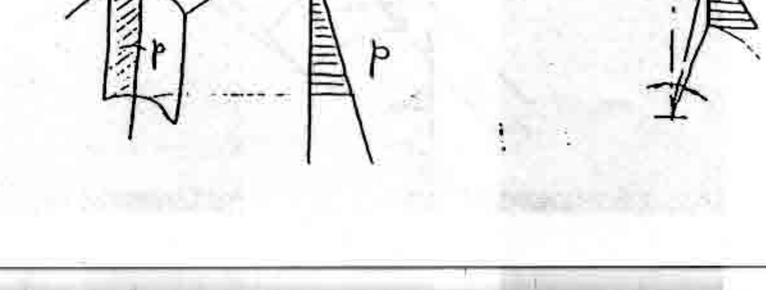


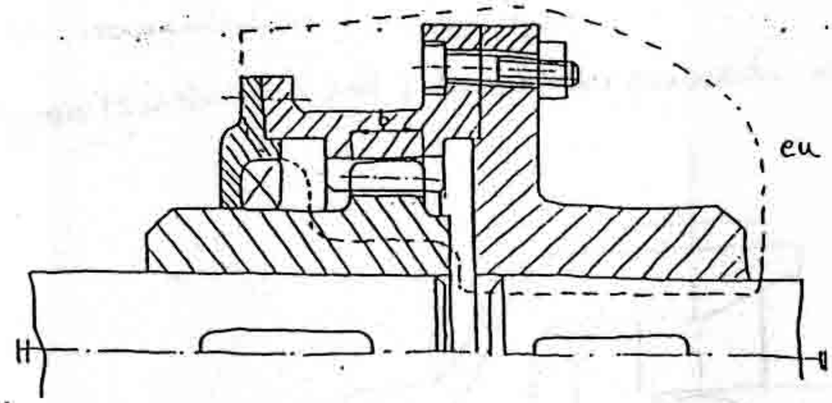
$\omega_1 = \text{konst.}$

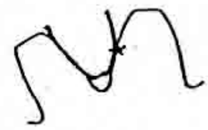
$\omega_2 = \omega_1$

$\omega_{SR} = \omega_1$

$\omega_{OPLET} = 2\,\omega_1$

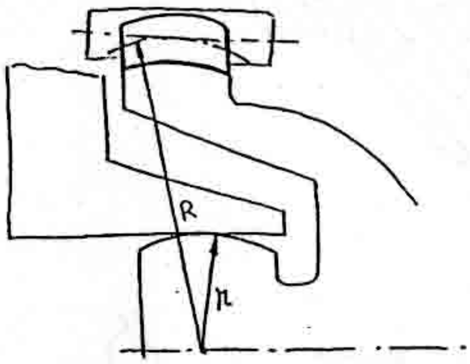






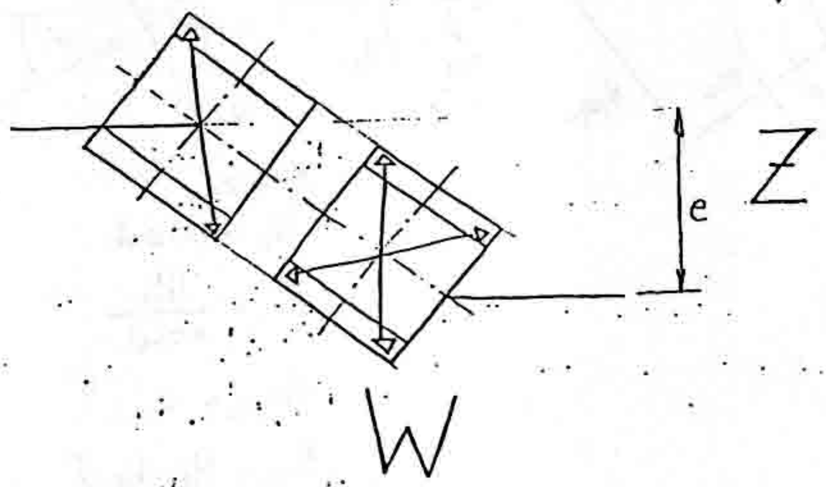
Zobji izdelani s Fellows postopkom. Možen ~~[illegible]~~ aksialni po

*DVOJNA ZOBATA SKLOPKA: [35.1]



- vodenje notranjega ozobja
- pokrov je centriran
- prilagodni vijak
- možno mazanje z mastjo

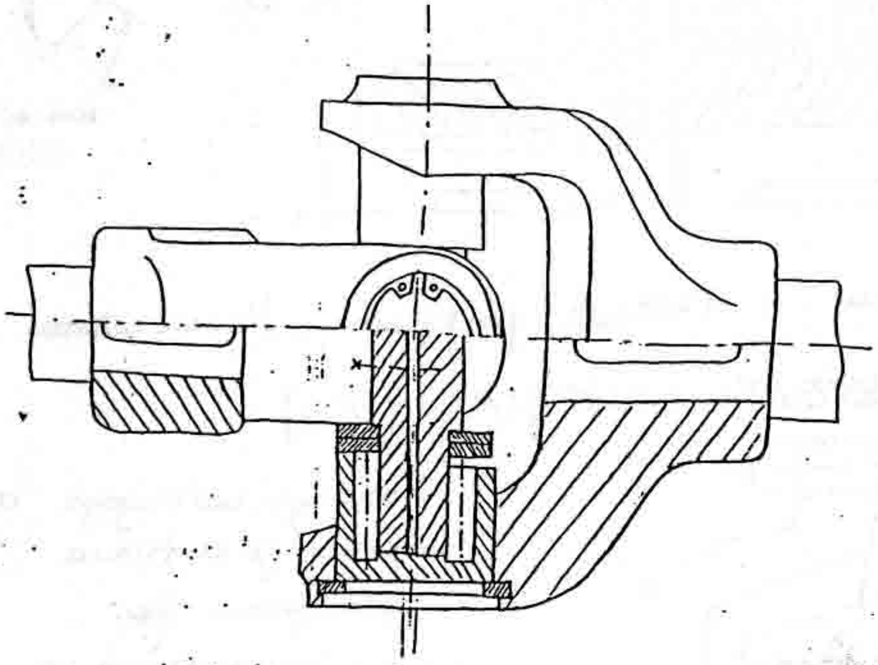
Možen tek gredi pri prelomljenih osih, dovoljen tudi majhen aksialen

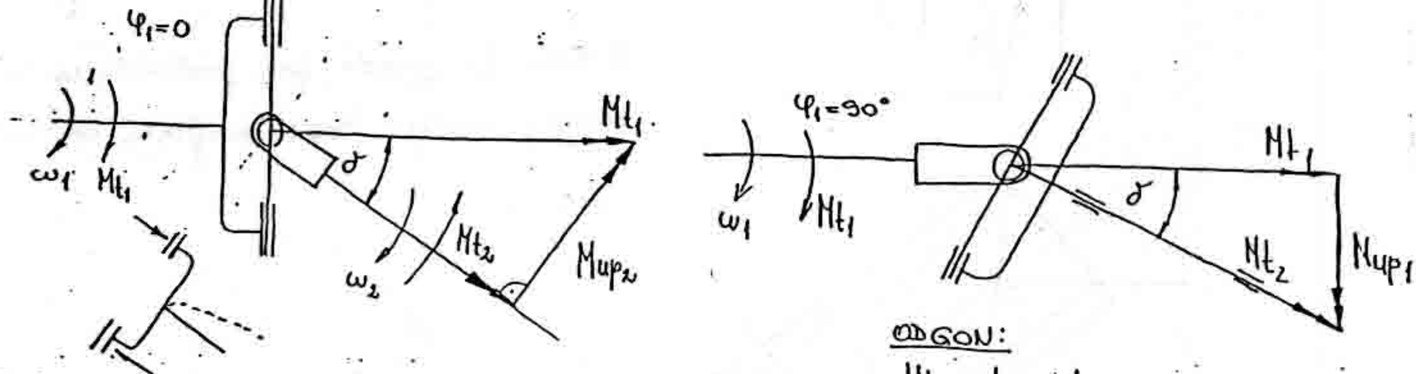


Dimenzioniranje:

- moznik
- ali ni točkovni dotik bombiranega ozobja prevelik
- kontrola vijaka

Ležaj dimenzioniramo na statično nosilnost, ker ni intenzivnega vrtenja





POGON:

$P_{do} = M_{t1} \cdot \omega_1 = konst.$

$M_{t1} = konst.$

$\omega_1 = konst.$

$M_{t2} = M_{t1} \cdot \cos\delta$

$M_{up2} = M_{t1} \cdot \sin\delta$

$M_{up1} = \emptyset$

$M_{t1} \cdot \omega_1 = M_{t2}\, \omega_2$

$M_{t1} \cdot \omega_1 = M_{t1} \cos\delta \cdot \omega_2$

$$\boxed{\omega_2 = \frac{\omega_1}{\cos\delta}}$$

ODGON:

$M_{t1} = konst$

$M_{t2} = \frac{M_{t1}}{\cos\delta}$

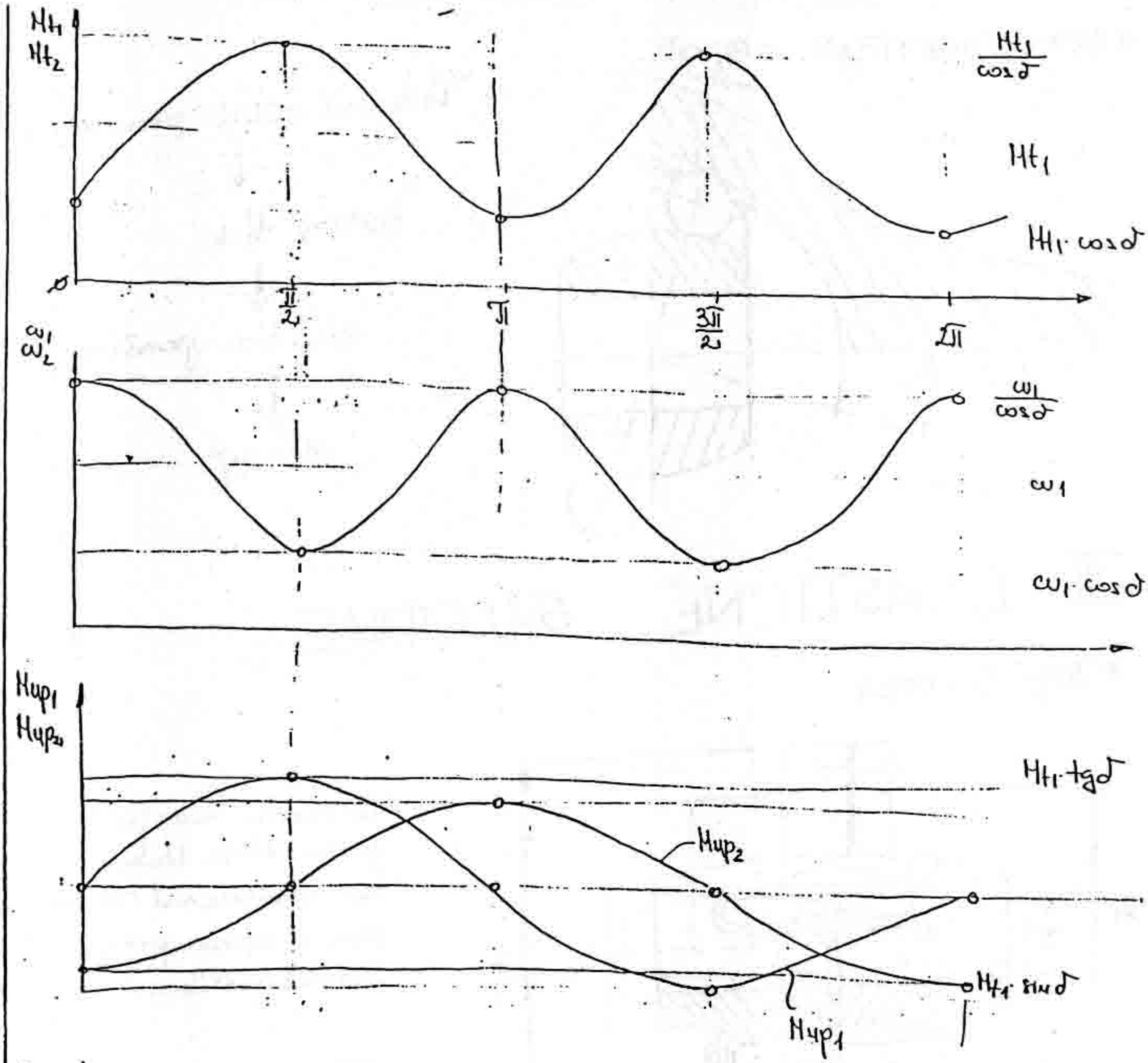
$M_{up2} = 0$

$M_{up1} = M_{t1} \cdot tg\,\delta$

$M_{t1} \cdot \omega_1 = M_{t2} \cdot \omega_2$

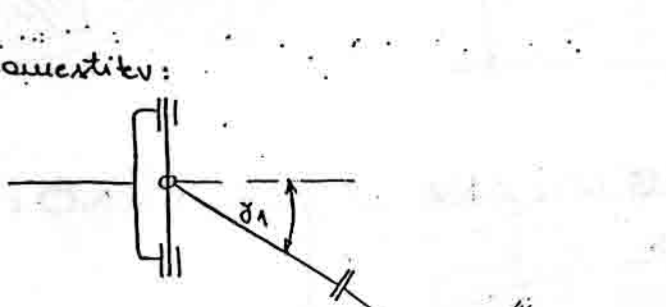
$M_{t1} \cdot \omega_1 = \frac{M_{t1}}{\cos\delta} \cdot \omega_2$

$$\boxed{\omega_2 = \omega_1 \cdot \cos\delta}$$ zaganjanje odgona

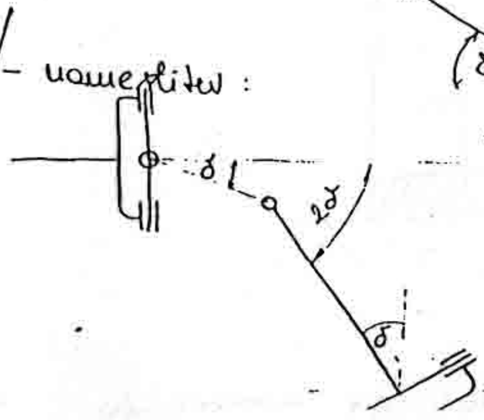


D. N.

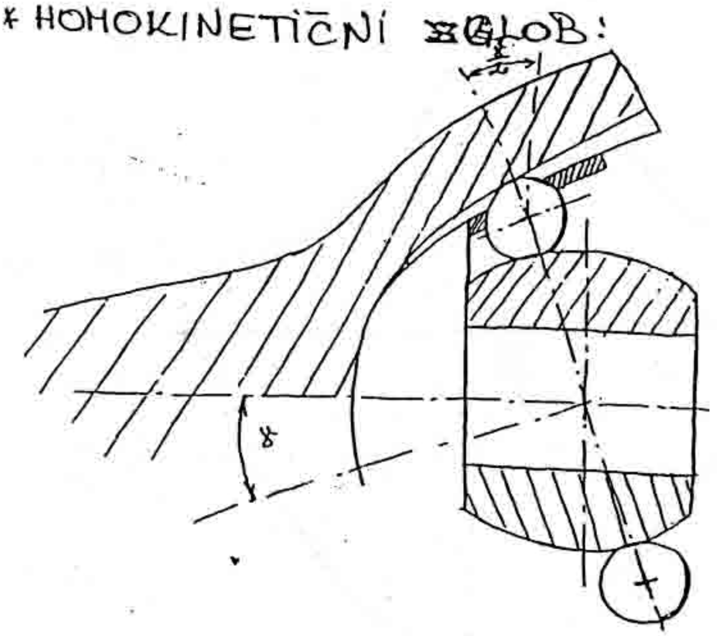
Z - наместитев:



W - наместитев:



* HOMOKINETIČNI ZGLOB:



Točkovni dotik prenosa sil

↓

Hertzov tlak

↓

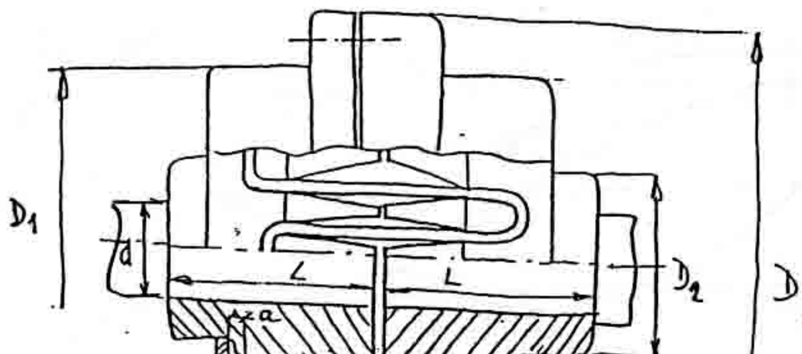
zelo trde površine

↓

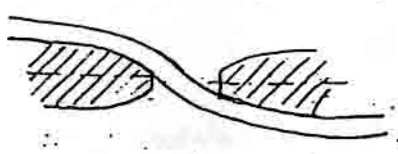
mazanje

III. ELASTIČNE SKLOPKE:

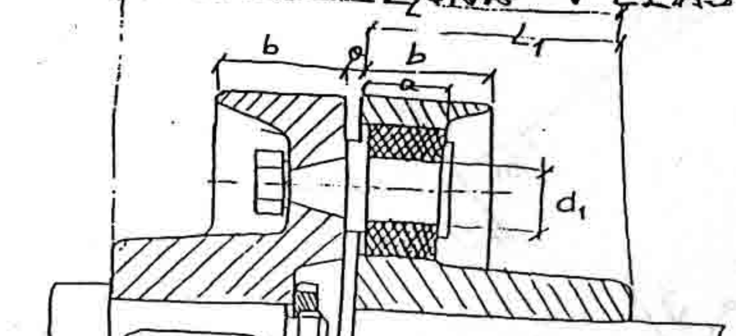
* BIBY SKLOPKA



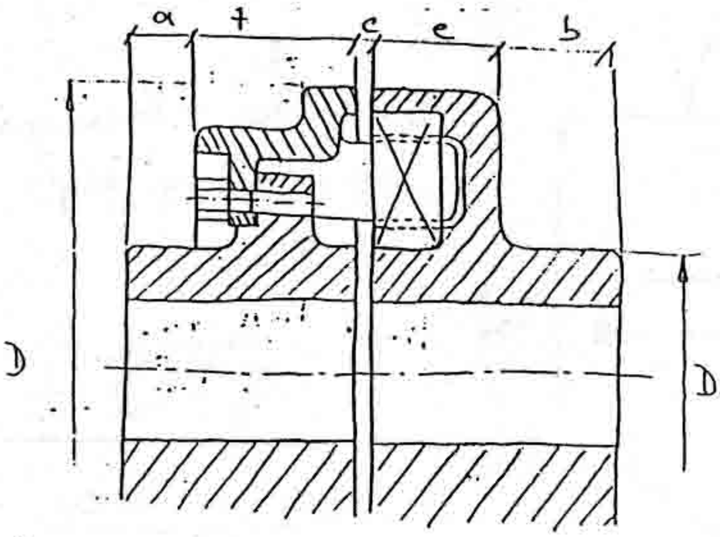
Po obodu navijemo jeklen trak. Nosovi so oblikovani tako da dobimo progresivno karakteristiko.

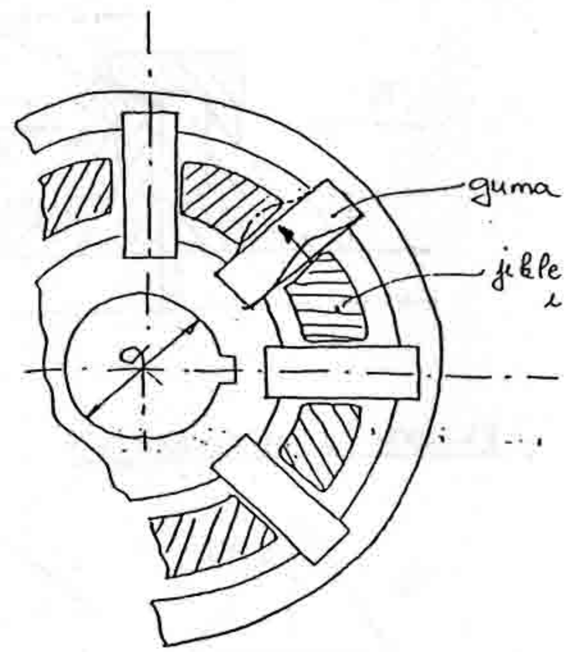


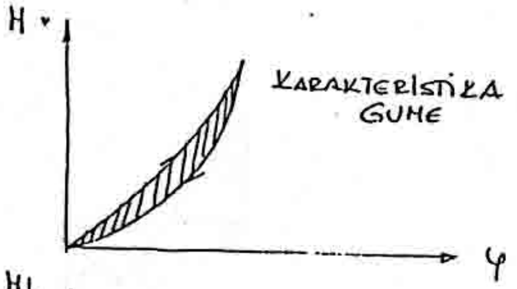
OBLIKOVNA SKLOPKA PREDELANA V ELASTIČNO:

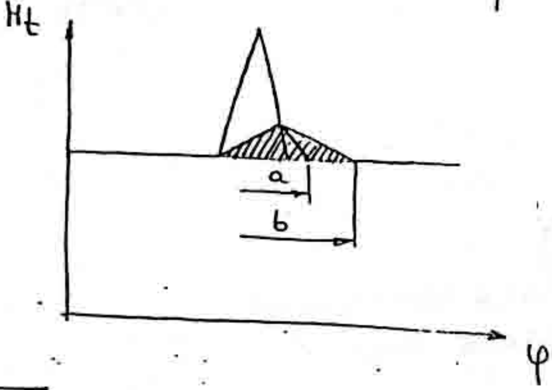


V torzijski smeri elastičen prenos vrtilnega momenta







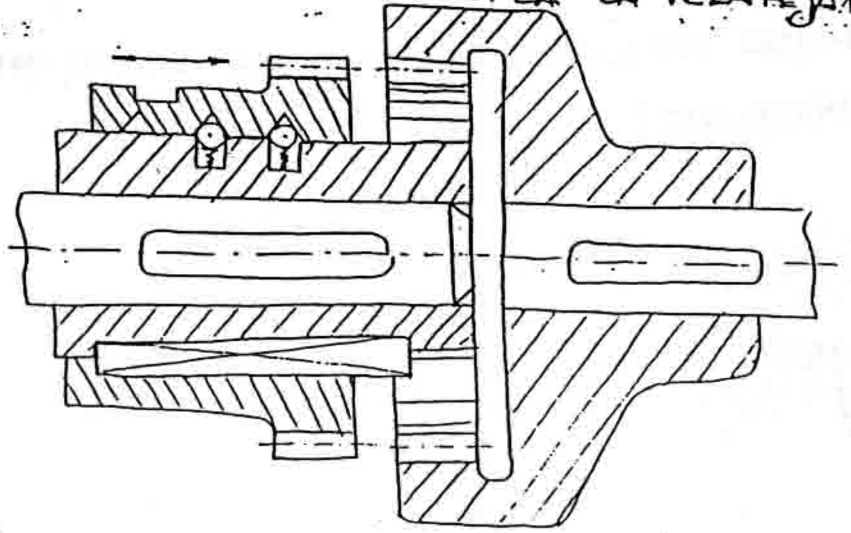


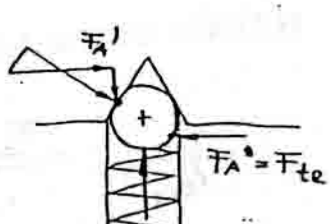
a) z elastičnim elementom

b) brez elastičnega elementa

IV. SKLOPKA ZA VKLAPLJ.

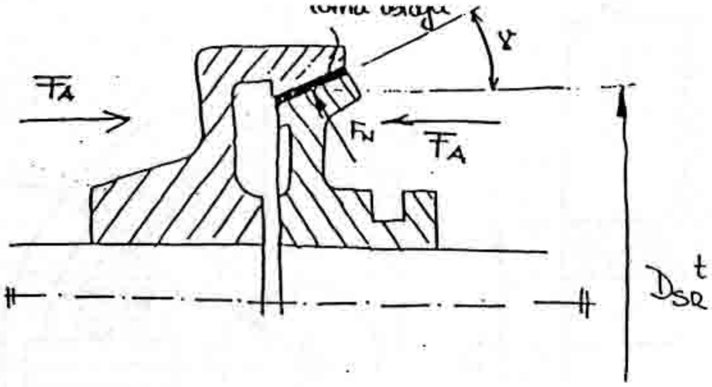
* OBLIKOVNA ~~TORNA~~ SKLOPKA ZA VKLAPLJANJE





utor narejen kot drsni ležaj

Kotne hitrosti na levem in desnem delu morajo biti enaki ob preklopu.



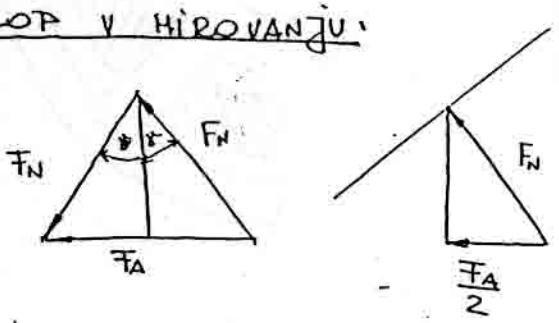
$$F_N \cdot \mu_g^m \cdot D_{SR}^t = M_{t\,VKLOPA}$$

$$\rho = \operatorname{arc\,tg} \mu_g$$

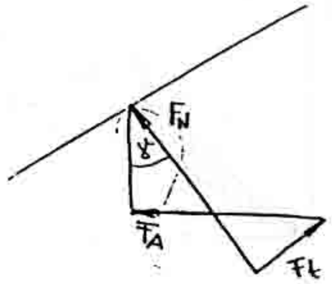
$$\operatorname{tg} \rho = \mu_g$$

$$F_N = \frac{M_{t\,VKLOPA}}{\operatorname{tg} \rho \cdot D_{SR}^t}$$

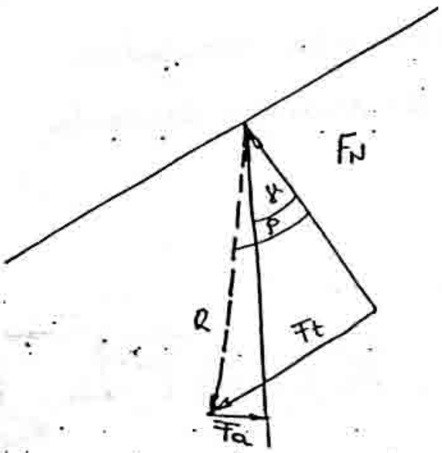
1.) VKLOP V MIROVANJU:



2.) VKLOP V TEKU



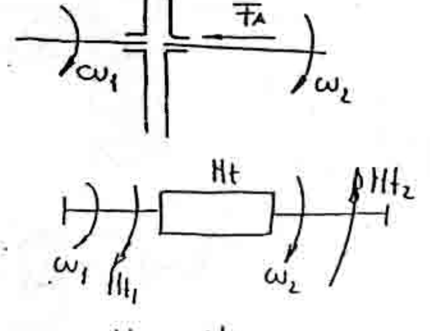
3.) RAZMERE PRI IZKLOPU:



$\boxed{\gamma < \rho}$

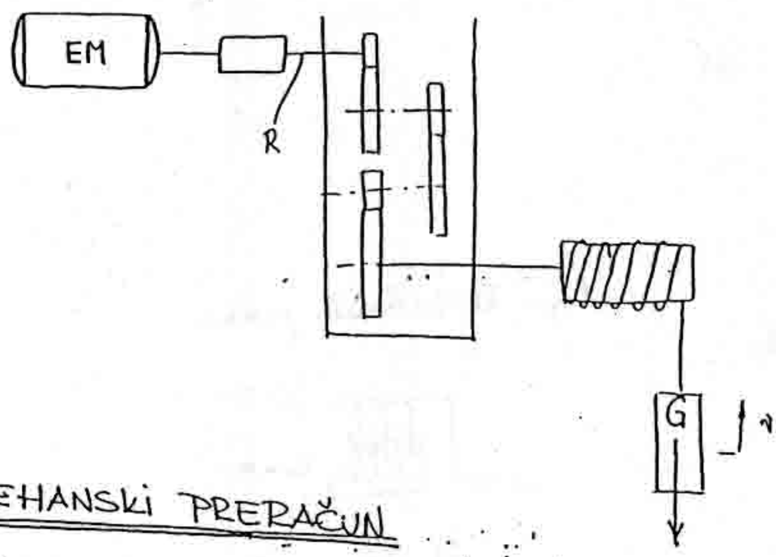
SKLOPKA TEKLA VKLOPLJENA BREZ ZUNANJE SILE.

* TOPLOTNI IN MEHANSKI PRERAČUN SKLOPKE ZA VKLAPLJANJE. NARIŠI USTREZNE DIAGRAME!



$M_{t_1} - M_{t_2}$

$\omega_1 - \omega_2$

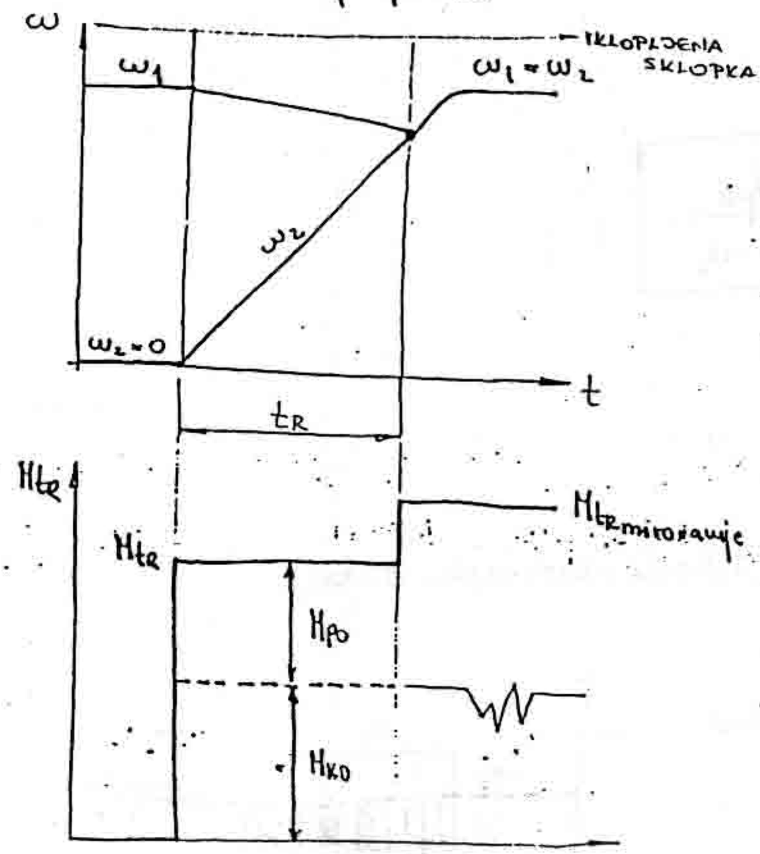


1) MEHANSKI PRERAČUN

$v = 0$, $\omega_2 = 0$, $\omega_1 = konst$

$M_{tr} = M_{ko} + M_{po}$

M_{ko} - koristni moment za dvig koluta
M_{po} - moment pospeška



t_R - čas vklopa (odgon lovi pogon)

z - začetka

$$\left[J_R \cdot \frac{\omega_2^2}{2} - \cancel{J_R \cdot \frac{\omega_{2z}^2}{2}} \right] = \left[J_1 \cdot \frac{\omega_1^2}{2} - \cancel{J_1 \frac{\omega_{2z}^2}{2}} + \dots + \frac{m \cdot v_2^2}{2} - \cancel{\frac{m \cdot v_{2z}^2}{2}} \right]$$

$\omega_R = \omega_2$

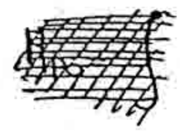
J_R - reduciran vstrajnostni moment

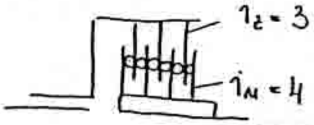
$$J_R \cdot \frac{\omega_2^2}{2} = \int_{t_R} M_{po} \cdot \omega_2(t) \cdot dt$$

$$M_{po} = M_{tR} - M_{ko}$$

$$M_{tR} = F_A \cdot \mu_g \cdot R_{sR}^{t} \cdot i_{tp}$$

i_{tp} - število tornih površin





$$\underline{i_{tp} = (i_z + i_N) - 1 = 6}$$

$$W_{po} = \int_{t_R} M_{po} \cdot \omega_2(t)\, dt$$

$$W_{po} = M_{po} \cdot \cancel{\omega_2} \frac{t_R}{\cancel{2}} = J_R \cdot \frac{\omega_2^{\cancel{2}}}{\cancel{2}}$$

$$t_R = \left(\frac{\cancel{2} \cdot M_p}{J_R \cdot \omega_2}\right)^{-1}$$

$$\boxed{t_R = \frac{J_R \cdot \omega_2}{\cancel{2} \cdot M_{po}} = \frac{2 \cdot W_{po}}{M_{po} \cdot \omega_2}}$$

<u>merilo obrabe je specifični tlak:</u>

$$p = \frac{F_A}{\frac{\pi}{4}\left(d_z^2 - d_n^2\right)}$$

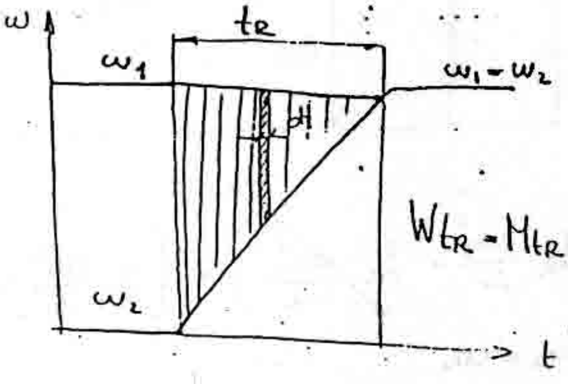
$p \leq p_{dop}$ (meh. mat., razlike hitrosti, življenjska doba)

∴) TOPLOTNI PRERAČUN:

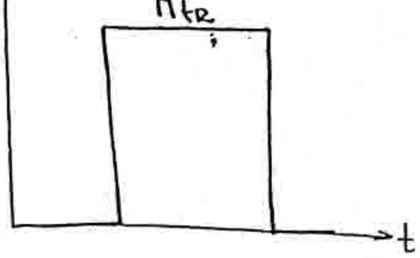
poškodba zaradi toplotnega toka:

$$W_{tR} = \int_{t_R} M_{tR} \left(\omega_1 - \omega_2(t)\right) dt$$

$$W_{tR} = M_{tR} \cdot \int_{t_R} \left(\omega_1 - \omega_2(t)\right) dt$$



$$W_{tR} = M_{tR} \cdot \frac{\omega_2 \cdot t_R}{2}$$



$$q = \frac{W_{tR}}{n_{tp} \cdot \frac{\pi}{4} \cdot \left(d_z^2 - d_n^2\right)}$$

$q \leq q_{mejni}$ (material, hlajenje, mazanje)

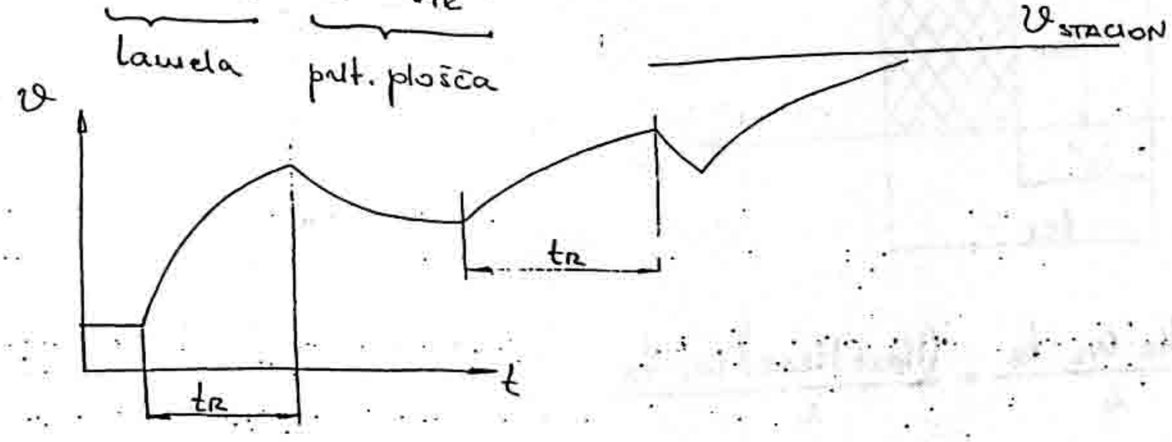
$$W_{tR} = c_l \cdot m_l \left(\vartheta_{lk} - \vartheta_{lz}\right) + c_{pp} \cdot m_{pp} \left(\vartheta_{ppk} - \vartheta_{ppz}\right) + c_v \cdot m_v \left(\vartheta_{vk} - \vartheta_{vz}\right) + \dots$$

l – lamela

pp – potisna plošča

v – vstrajnik

$$W_{te} = \underbrace{0{,}2\, W_{tr}}_{\text{lamela}} + \underbrace{0{,}5 \cdot W_{te}}_{\text{pot. plošča}} + \dots$$



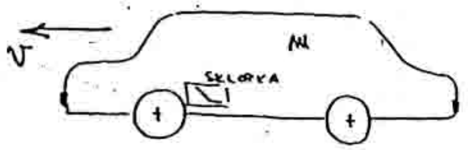
$$\underbrace{z \cdot W_{tR}}_{\text{toplotni tok}} = \frac{1}{2} z \cdot M_{te} \cdot \omega_2 \cdot t_R$$

$$z \cdot W_{tR} = \alpha \cdot A \cdot \left(\vartheta_{pov_k} - \vartheta_{HS}\right)$$

HS – hladilno sredstvo

$$\boxed{\vartheta_{pov\,k} = \frac{z \cdot W_{tR}}{\alpha A} + \vartheta_{HS}}$$

Sopotanske momente pri avtomobilu

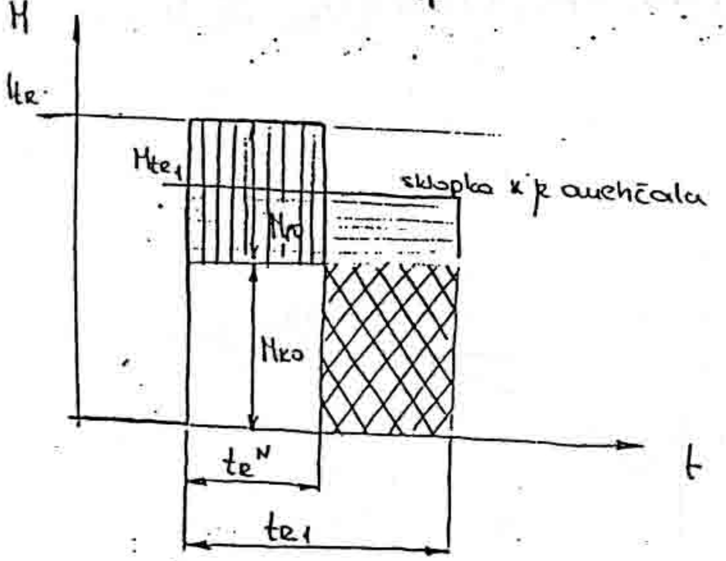


$W_{po} = \emptyset$

$$t_R = \frac{2 \cdot W_{po}}{M_{po} \cdot \omega_2}$$

$M_{te} = M_{ko} + M_{po}$

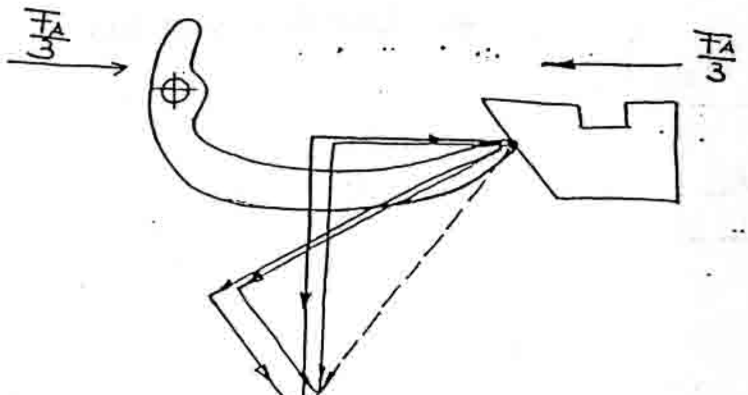
$M_{tR} = F_A \cdot \mu_g \cdot R_{se}^t \cdot i_{tp}$



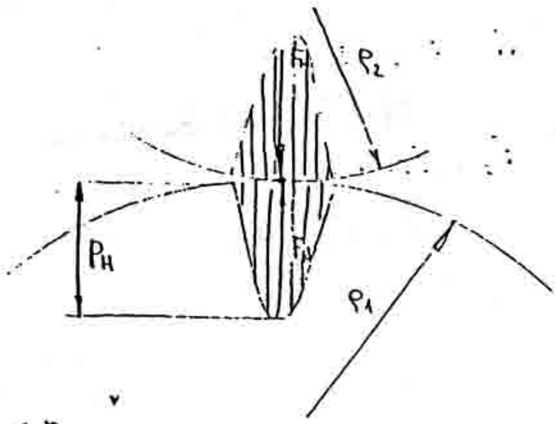
$$W_{tR} = \frac{M_{te} \cdot \omega_2 \cdot t_R}{2} = \frac{(M_{po} + M_{koR}) \cdot \omega_2 \cdot t_R}{2}$$

$M_{koR} \cdot t_r = konst.$

LAMELNA SKLOPKA: [112. 1]



... sprejmemo odmevne & HERTZOV TLAK



$$k_1 = \frac{F_N}{2b \cdot \rho_{sR}}$$

$k \leq k_{dop}$ (mehkejšega materiala, števila sil, L_h)

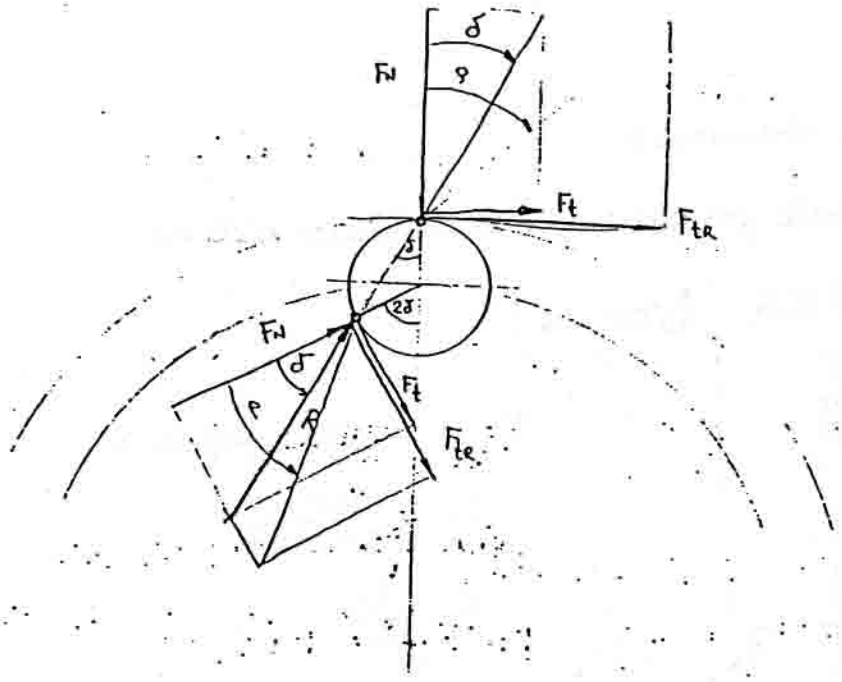
$$\frac{1}{\rho_{sR}} = \frac{1}{\rho_1} \pm \frac{1}{\rho_2}$$

$p_H < p_{H\,dop}$

+ ... konveksno - konveksno

− ... konveksno - konkavno

45.) ENOSMERNA ZAVORA Z VALJČKI: [147.1]



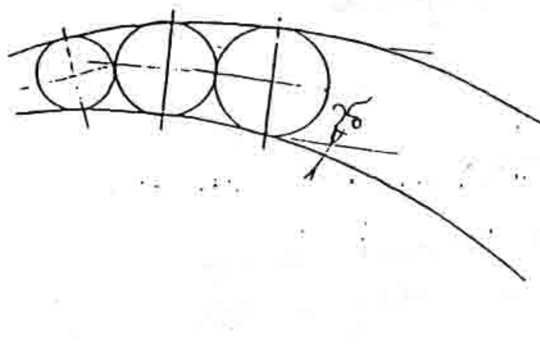
$1{,}1 \cdot tg\,\delta = tg\,\rho$

$1{,}1 \cdot tg\,\delta = \min\{\rho_z, \rho_s\}$

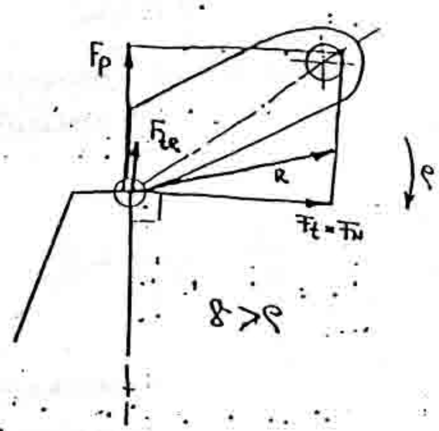
$tg\,\rho = \mu$

Izraba valjčkov:

arhimedova spirala



* SKLOPKA ZA PROSTI TEK (zapora z zaskočko) [135.1]



$F_p > F_{tR} \Rightarrow$ zaskočka pade

$F_{tR} = F_T \cdot \mu_m$

PRERAČUN:

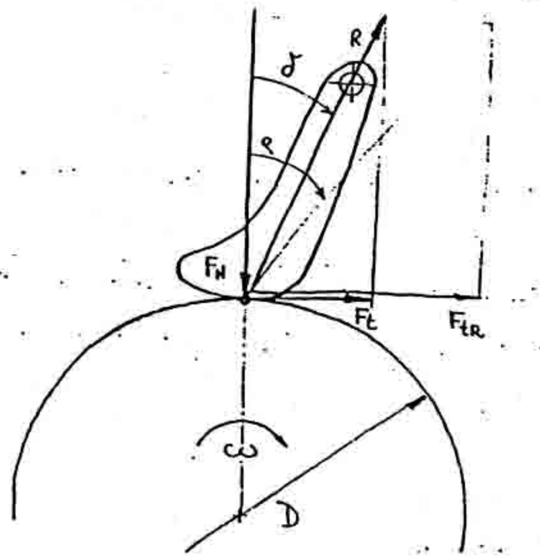
$k_b = \frac{F_N}{b} \quad \left[\frac{N}{mm}\right]$

$k_b \leq k_{b_{mejni}}$

k_b - specifična linijska obremenitev.

Č postavimo več zaskočk po obodu, zmanjšamo delitev.

* TORNA SKLOPKA [COKLA]



$\rho > \delta$ cokla poprime

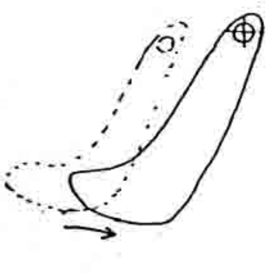
$F_{tR} = \frac{2 M t_{max}}{D}$

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

$1{,}1 \cdot tg\,\delta = tg\,\rho$

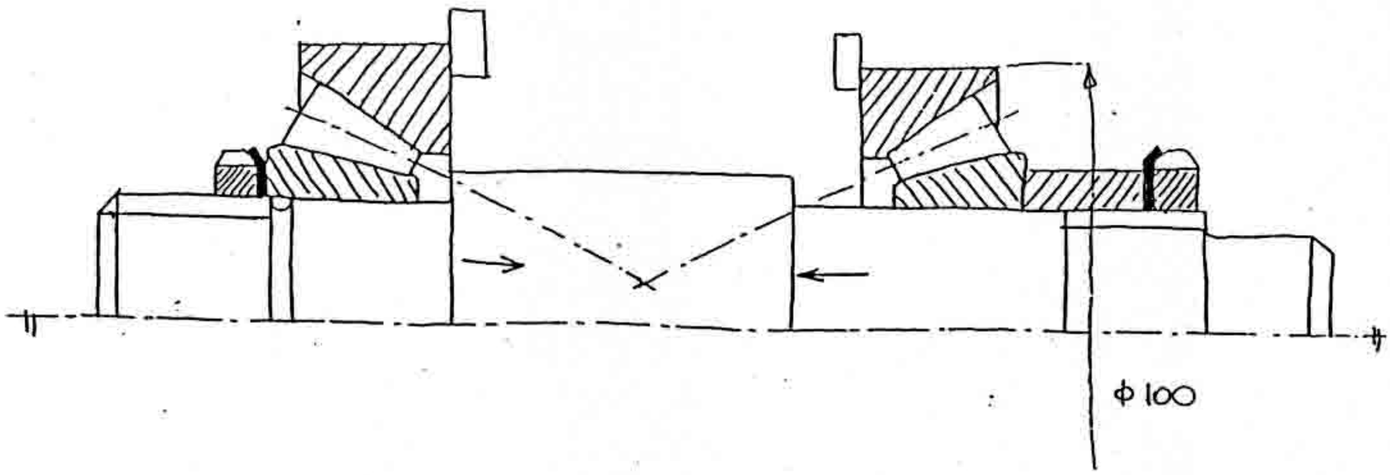
ρ ki odvisen od materiala, ki v prijemu

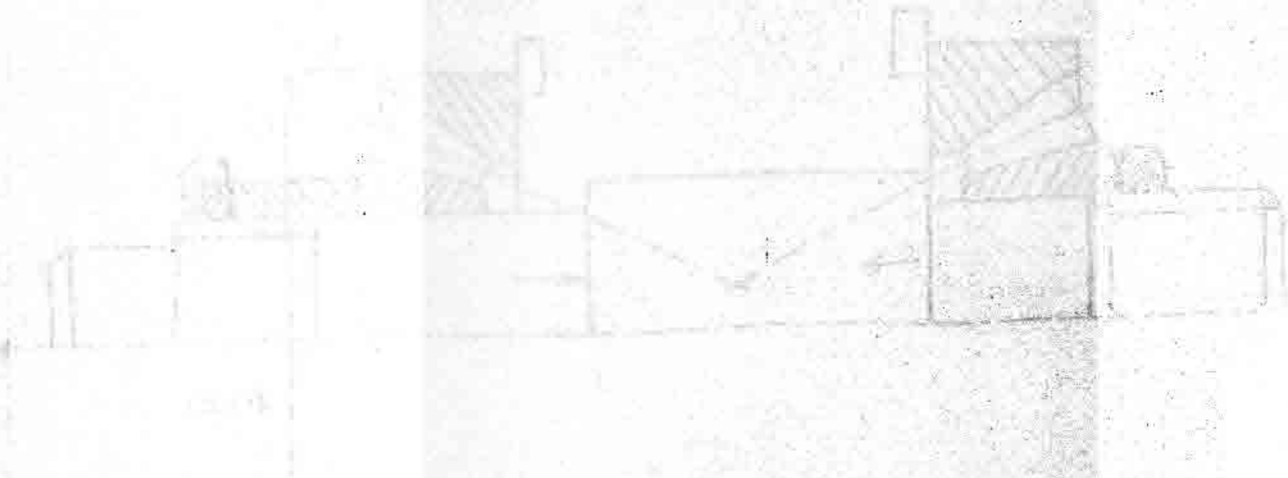
Po obrabi se točka oprijema premakne



Dimenzionirat sornik na upogib, strig in tlak

UPOGIB GREDI.

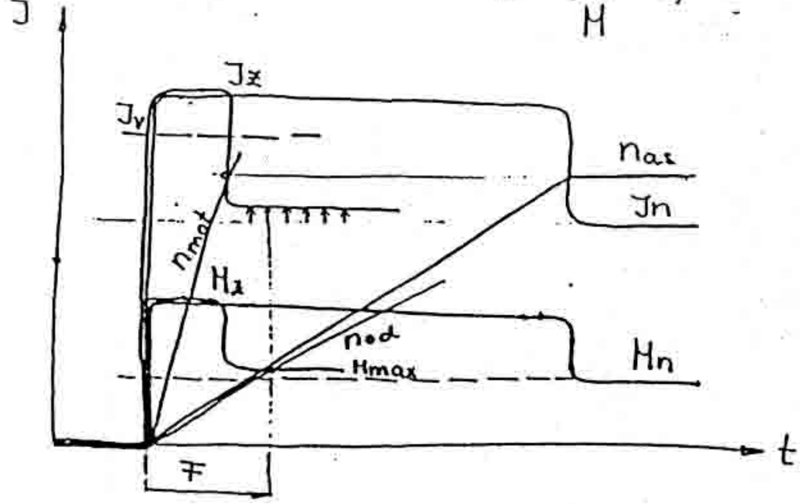




... SKLOPKE

- kontrola momenta za varovanje [150.2] F_a = konst
- zagonska sklopka [159.2] $M_{tr} = F_a \cdot \mu_m \cdot R_{sr}^t$

Diagram zagona za (159.2) (J-t) M



Jz - zagonski tok

Jn - nazivni tok

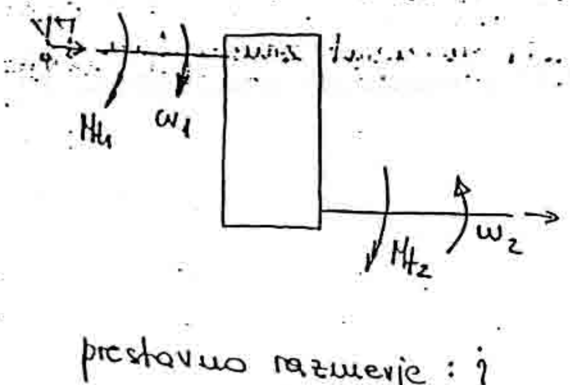
Mz - zagonski momen

Mn - nazivni momen

Jv - varovalka

GONILA:

Prenosniki za prenos vrtilnega gibanja omogoča transformacij mehanske energije.

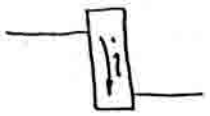


prestavno razmerje : i

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

$\omega_1 = V$

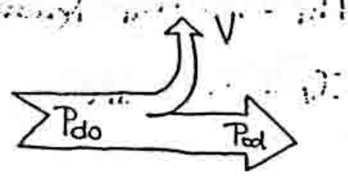
$M_{t1} = V$



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

$P_{do} = M_{t1} \cdot \omega_1$

$(P_{od} = ?)$



$$\eta = \frac{P_{od}}{P_{do}}$$

$V = P_{do} - P_{od} = P_{do}(1-\eta)$

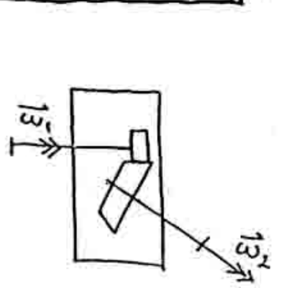
$$\boxed{V = P_{do}(1-\eta)}$$

$P_{od} = \eta \cdot P_{do}$

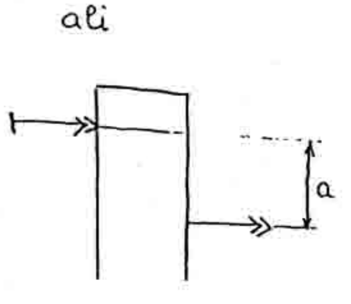
$M_{t2}\omega_2 = \eta \, M_{t1}\omega_1$

$M_{t2} \cdot \omega_2 = \eta \cdot M_{t1} \cdot i \cdot \omega_2$

$\boxed{M_{t2} = \eta \cdot i \cdot M_{t1}}$: Zaradi izgub je odgonski moment zmanjšan !!

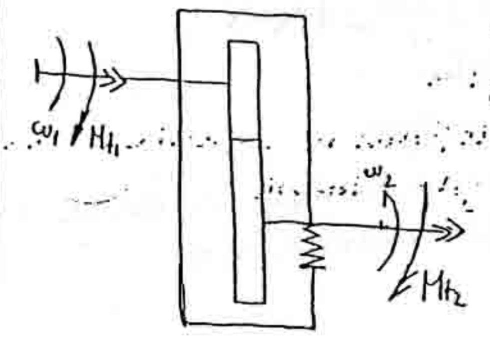


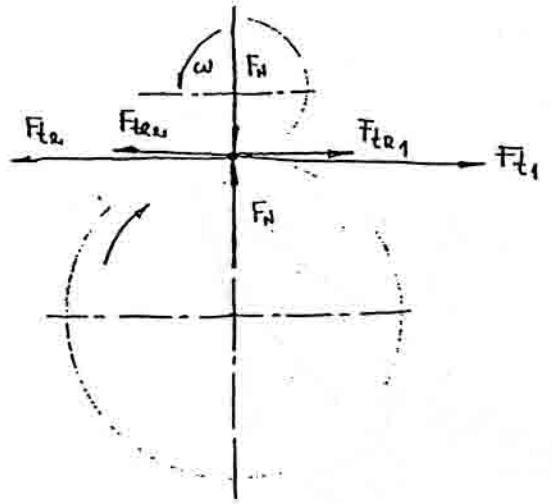
ali

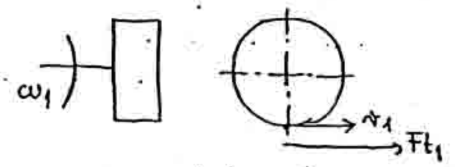


I. GONILA S PRENOSOM S TRENJEM

1. TORNA GONILA:







$P_{do} = F_{t1} \cdot v_1$

$v_1 = \text{velik}$

$F_{t1} = \text{velik} \rightarrow F_{tr} = \text{velik}$

$v_1 = r_1 \cdot \omega_1$

$r_1 \rightarrow$ povečujem

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

$F_{tr} = \text{velik}$

$F_N = \text{velik}$ (povečam)

μ (povečam)

Kotalni prenos pri povečanem $F_N \rightarrow$ večam HERTZOV TLAK

TRDI TORNI MATERIAL:

kovina / kovina

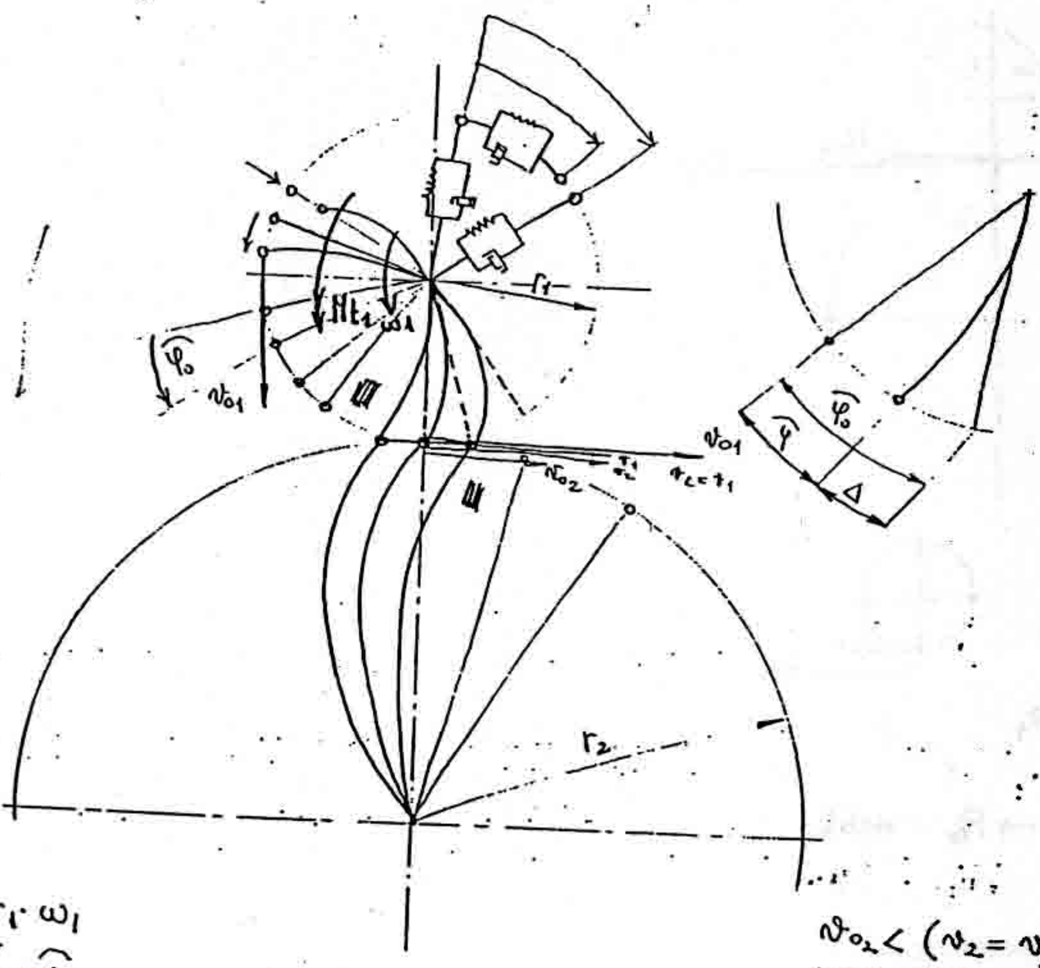
- μ - majhen
- p_H - je velik
- malo izgub
- dobri prevodniki toplote

MEHKI TORNI MATERIAL:

torni mat. iz umetnih mas ali guma, les, papir

- μ - velik
- p_H - majhen
- veliko deformacij → velike izgube
- omejen odvod toplote

* RAZMERE PRI NAKOTALJEVANJU:



$v_{01} = r_1 \cdot \omega_1$

$\widehat{\varphi} = \widehat{\varphi_0} - \widehat{\Delta}$

$v_1 < v_{01}$

$v_1 = r_1 \cdot \omega_1 \cdot ?$

$? = f\left(\frac{\varphi}{\varphi_0}\right)$

$0 < \delta^{\pm} < 1$

tangencialni slip

$\boxed{\frac{v_{01} - v_1}{v_{01}}}$ +... pogon

$= 0 \Rightarrow v_{01} = v_1$ (ob čistem nakotaljevanju)

$= 1 \Rightarrow$ " $-$ " $($

$v_{02} < (v_2 = v_1)$

$\boxed{\delta^- = \frac{v_2 - v_{02}}{v_2}}$ ⊖... odgon

$\delta^- = 1$ (ni trenja na odgonu)

$\delta^- = 0$ (ni elastičnih deform.

$v_{02} = v_{01} \cdot (1 - \delta_1)(1 - \delta_2)$

$\omega_2 = \frac{v_{02}}{r_2}$

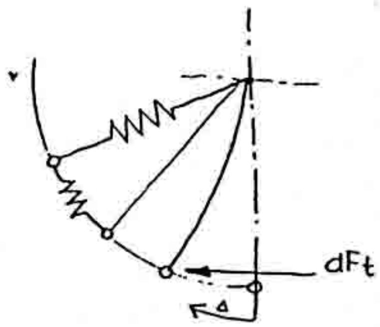
$$i = \frac{v_{o1}}{r_1} \cdot \frac{r_2}{v_{o2}} =$$

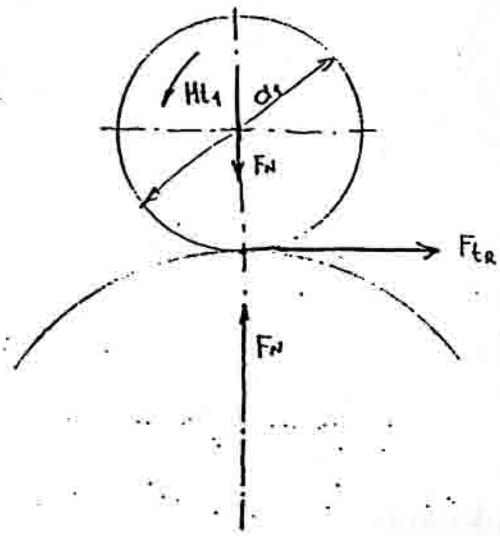
$$i = \frac{\cancel{v_{o1}}}{r_1} \cdot \frac{r_2}{\cancel{v_{o1}}(1-b_1)(1-b_2)}$$

$$\boxed{i = \frac{d_2}{d_1} \cdot \frac{1}{(1-b_1)(1-b_2)}}$$

Prestava ni konstantna, ker def. ne prenašajo vrtenje sinhrono

$$b_1, b_2 = f(Mt)$$
$$i = i(Mt)$$





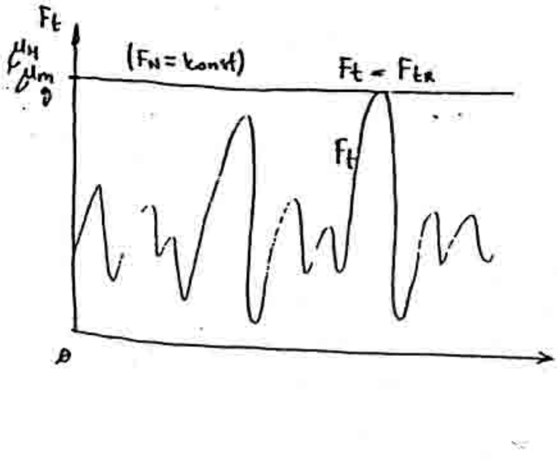
$$F_{tR} = F_N \cdot \mu$$
$$M_{t1} = \checkmark$$
$$F_{t1} = \frac{2M_{t1}}{d_1}$$
$$F_t \leq F_{tR}$$

$$\boxed{\mu_H = \frac{F_t}{F_N}}$$

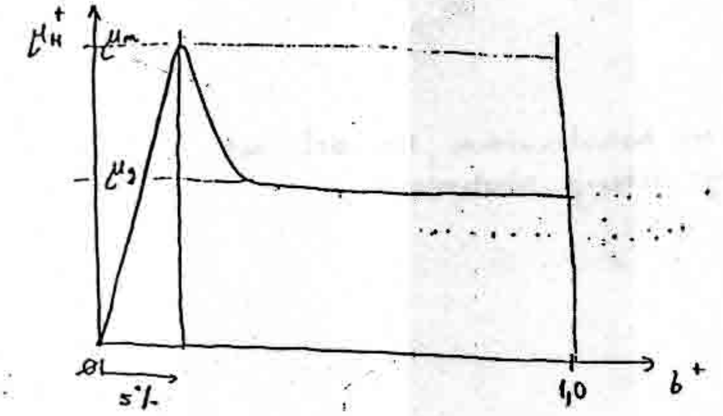
$\mu_H < \mu$

μ_H – koeficient sojemanja

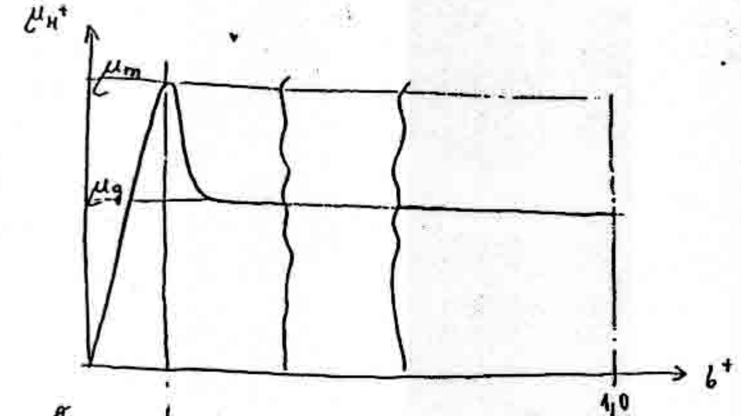
$$0 \leq \mu_H \leq \mu_{mg}$$



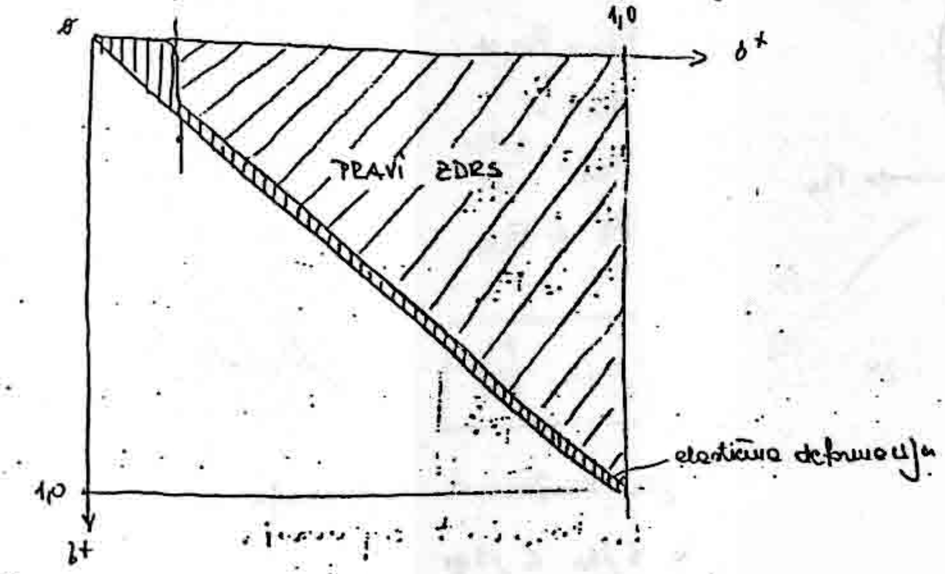
$= b(F_t)$
$= b(\mu_H)$



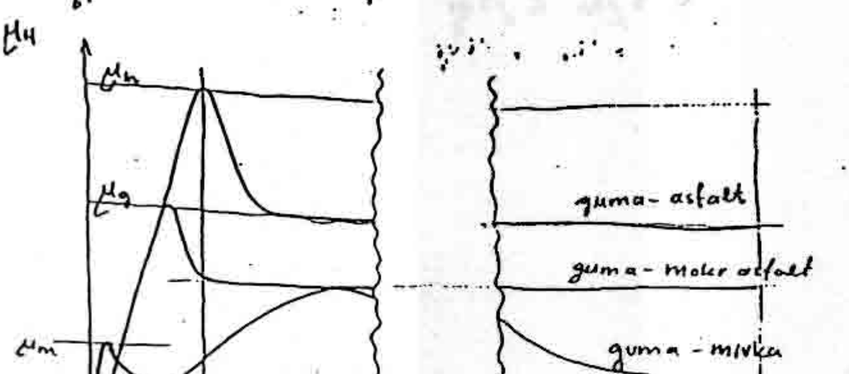
μ_H^+
μ_m
μ_g
0
5%
1,0
b^+



μ_H^+
μ_m
μ_g
1,0
b^+

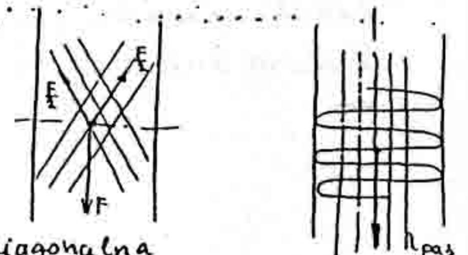


0
b^+
PRAVI ZDRS
elastična deformacija
1,0
b^+



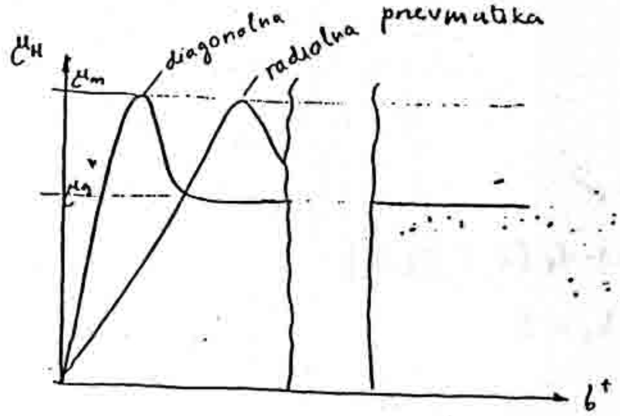
μ_H
μ_m
μ_g
μ_m
μ_g
guma-asfalt
guma-moker asfalt
guma-mivka
jeklo-jeklo
1,0
b

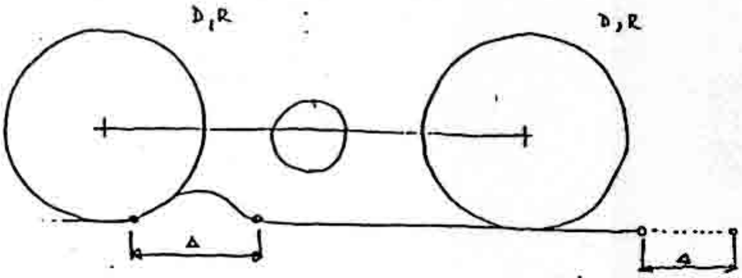
Avtomobilska pnevmatika



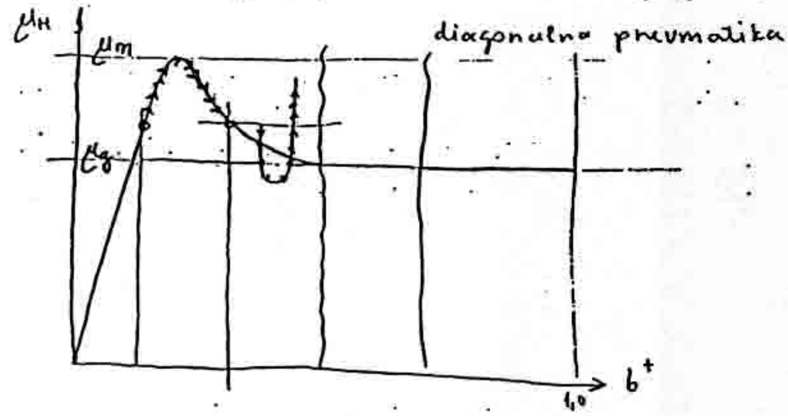
diagonalna pnevmatika

radialna pnevmatika

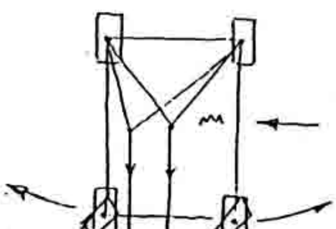




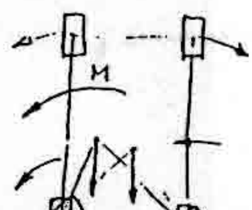
Δ - razlika poti



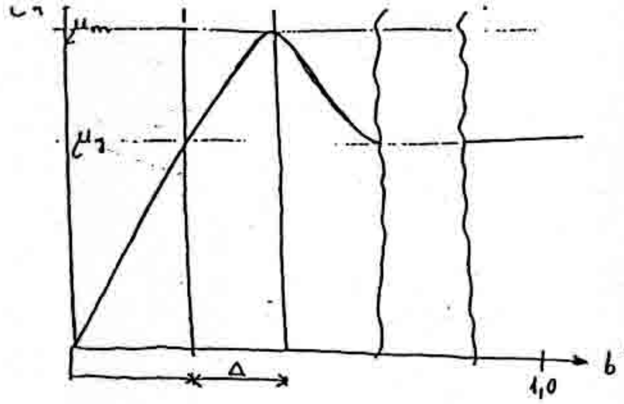
ZDRS SPREDNJIH KOLES.



ZDRS ZADNJIH KOLES:



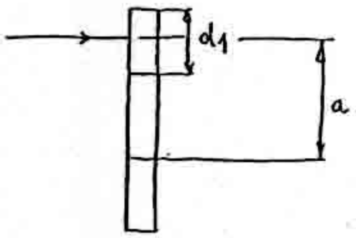
Boljši pnevmatike zmeraj na zadnja kolesa.



Slabost radialne pnevmatike je slabo prenašanje bocnih sil

IMENZIONIRANJE GONILA:

D0, m, i



$d_1 = \checkmark$

$d_2 = i \cdot d_1 \, (1-b_1)(1-b_2)$

$b_1, b_2 = ?$

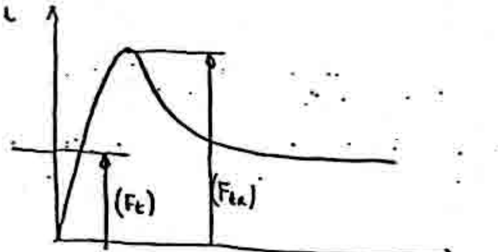
$F_{trm} = F_N \cdot \mu_m$

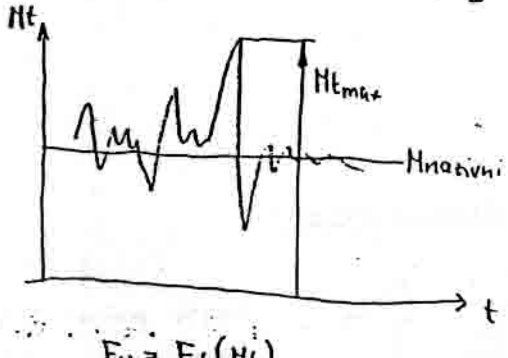
$F_N = ?$

$F_t \leq F_{tr}$

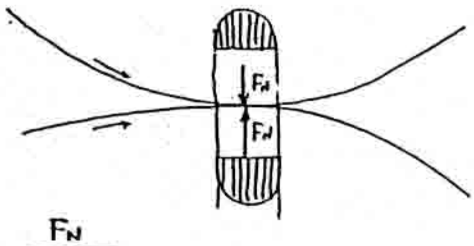
$F_N = \frac{2Mt}{d_1} \leq F_N \cdot \mu_m$

$$\boxed{F_N = \left(\frac{2Mt}{d_1 \cdot \mu_m}\right) \cdot S}$$





$F_N = F_N(M_t)$



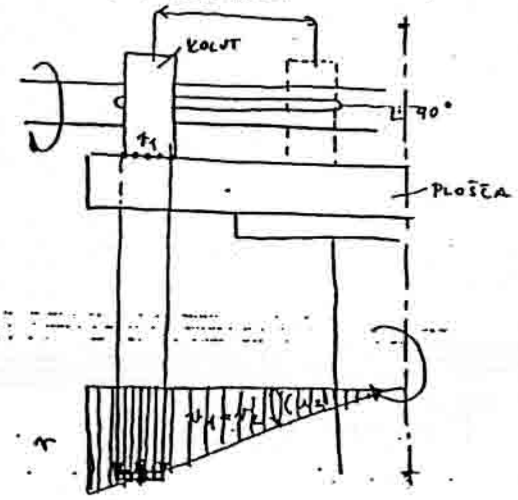
$$k = \frac{F_N}{2b\rho}$$

$$\frac{1}{\rho} = \frac{1}{\rho_1} \pm \frac{1}{\rho_2}$$

+ ... konvekno - konvekno
- ... konvekno - konkavno

$k \leq k_{dop}$ (mehkejšega mat., deformabilnost, odvajanje toplote)

DIFERENČNI ZDRS:



$$R_b = \frac{i_{max}}{i_{min}}$$

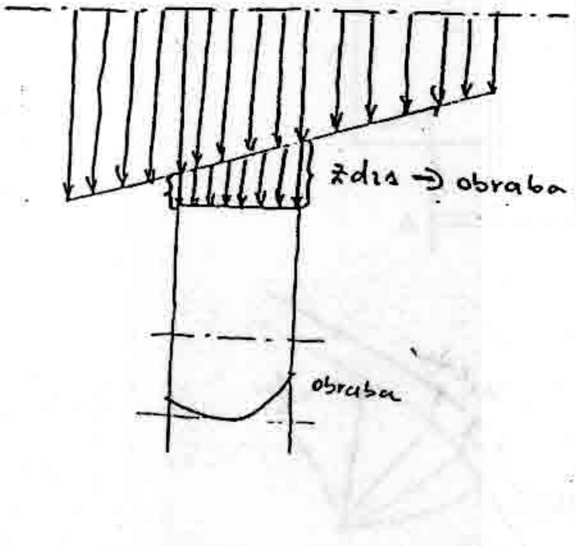
$$i = \frac{d_2}{d_1(1-\zeta_1)(1-\zeta_2)}$$

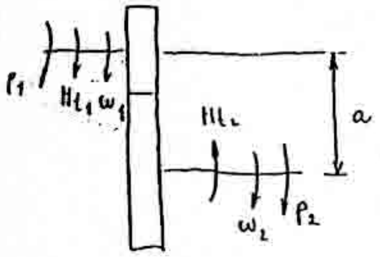
$$i_{max} = \frac{d_{2max}}{d_1(1-\zeta_1)(1-\zeta_2)}$$

$$i_{min} = \frac{d_{2min}}{d_1(1-\zeta_1)(1-\zeta_2)}$$

$$\boxed{i = \frac{d_{2max}}{d_{2min}}}$$

R_b - Regulacijsko območje





$$\eta = \frac{P_2}{P_1}$$

$$\eta = \frac{Mt_2 \cdot \omega_2}{Mt_1 \cdot \omega_1}$$

$$i = \frac{\omega_1}{\omega_2} = \frac{d_2}{d_1(1-b_1)(1-b_2)}$$

$$\eta = \frac{Mt_2}{Mt_1 \cdot i}$$

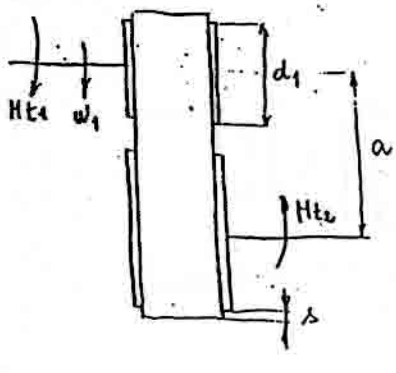
$$\frac{d_2}{d_1} = i_{teor.}$$

$$i = \frac{i_{teor}}{(1-b_1)(1-b_2)}$$

$$\boxed{\eta = (1-b_1)(1-b_2)}$$

JERMENSKI PRENOS:

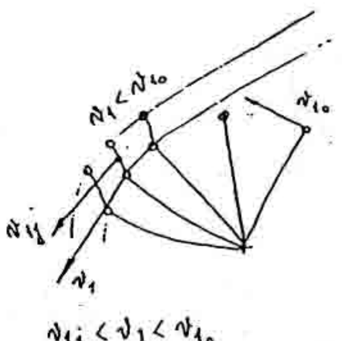
PLOŠČATI JERMEN:

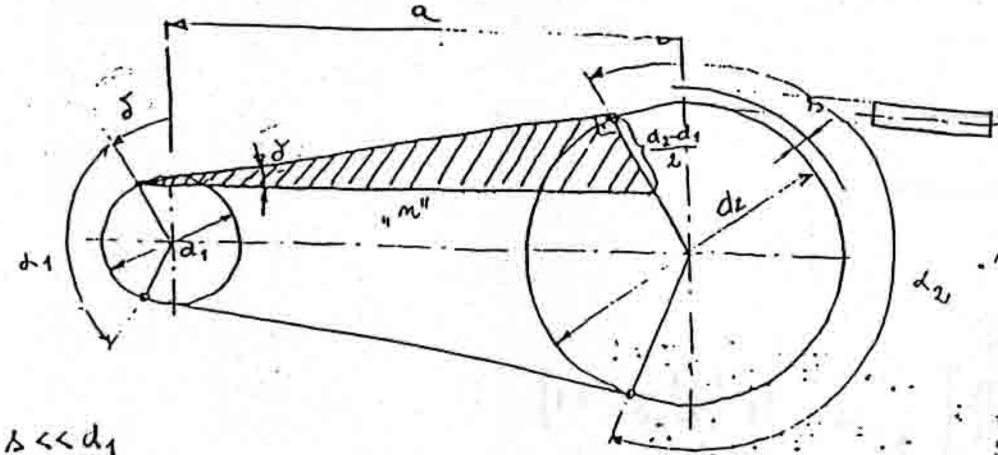


$$i = \frac{\omega_2}{\omega_1}$$

$$i = \frac{d_2}{d_1(1-b_{t_1})(1-b_{el})(1-b_{t_2})}$$

$$(b_{t_1}, b_{t_2}, b_{el}) = f(\mu)$$





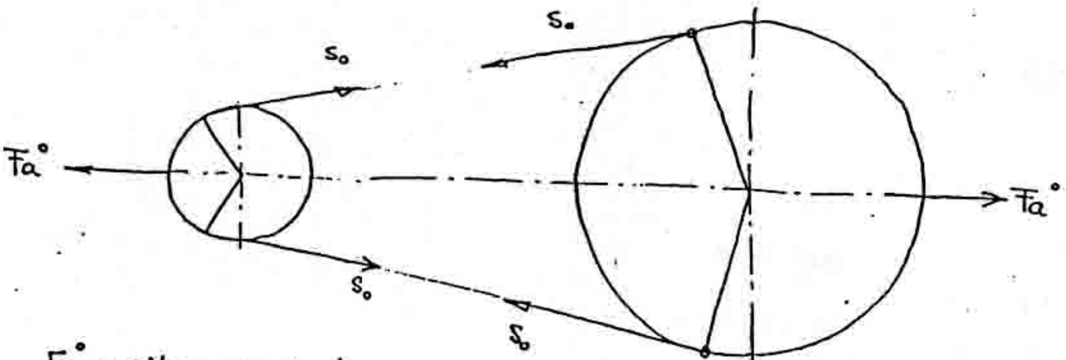
„n" – če gledamo notranje vlakno

$s << d_1$

$\sin\vartheta = \frac{d_2-d_1}{2a}$

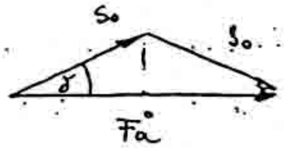
$\alpha_1 = 180 - 2\vartheta$

$\alpha_2 = 180 + 2\vartheta$

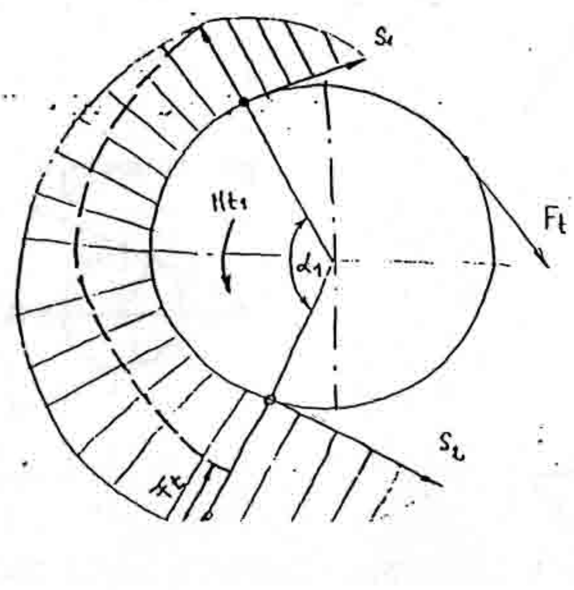


F_a° – sila napenjanja

S° – sila u jermenu



$\boxed{F_a = S_0 \cdot 2\cos\vartheta}$

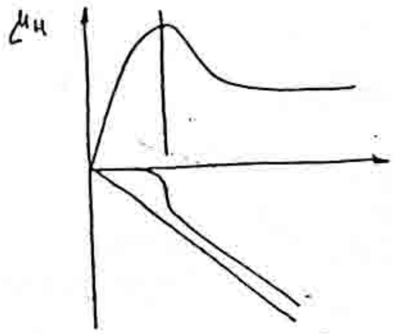


$S_2 - S_1 = F_t$

$F_t = \frac{2M_t}{d}$

$S_2 \cdot \frac{d_1}{2} = F_t \cdot \frac{d_1}{2} + S_1 \cdot \frac{d_1}{2}$

$\boxed{\frac{S_1}{S_2} = e^{\mu \widehat{\alpha_1}}}$ relja za računanje pri



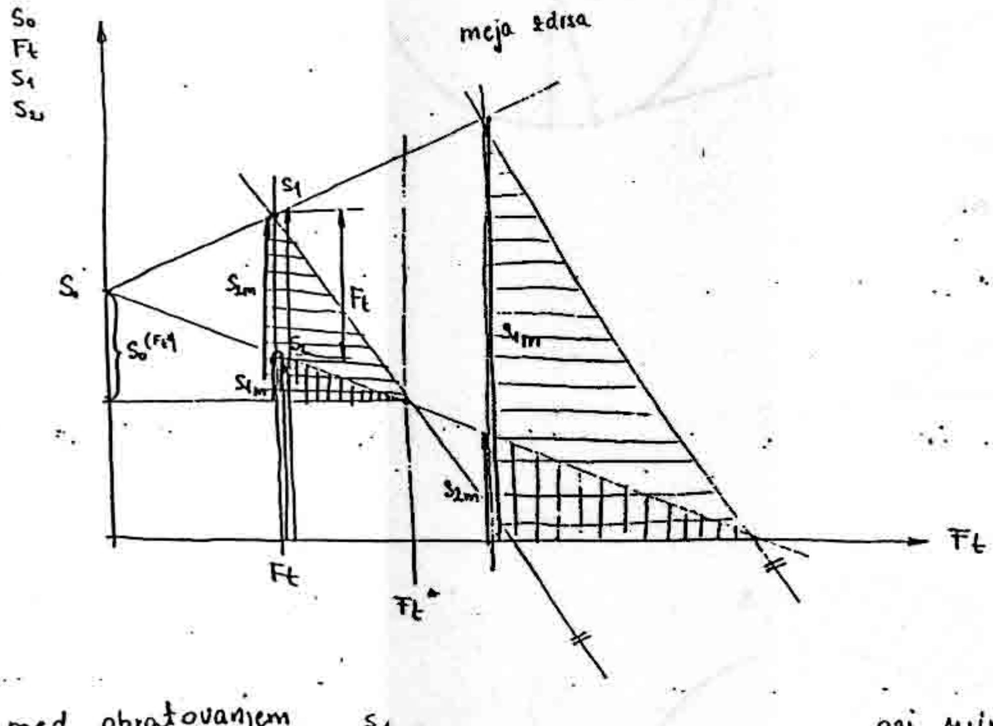
$$\left.\begin{aligned} S_1 - S_2 &= F_t = \frac{2M_t}{d_1} \\ \frac{S_1}{S_2} &= e^{\mu \widehat{\alpha_1}} \end{aligned}\right\} \Rightarrow \begin{aligned} S_1 &= F_t \left(\frac{1}{1-e^{\mu\alpha}} + 1\right) \\ S_2 &= F_t \cdot \left(\frac{1}{1-e^{\mu\alpha}}\right) \end{aligned}$$

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

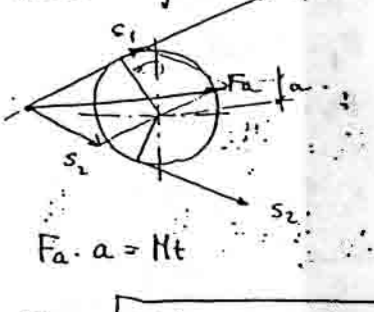
$\underline{\underline{F_a^{\circ} =}}$

$$0 \leq F_t \leq (S_1 - S_2)$$

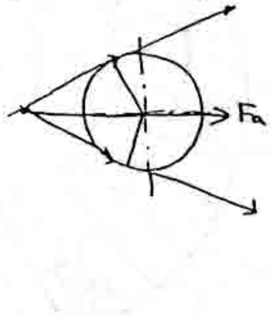
$$\frac{S_1}{S_2} = e^{\mu \widehat{\alpha_1}}$$



med obratovanjem



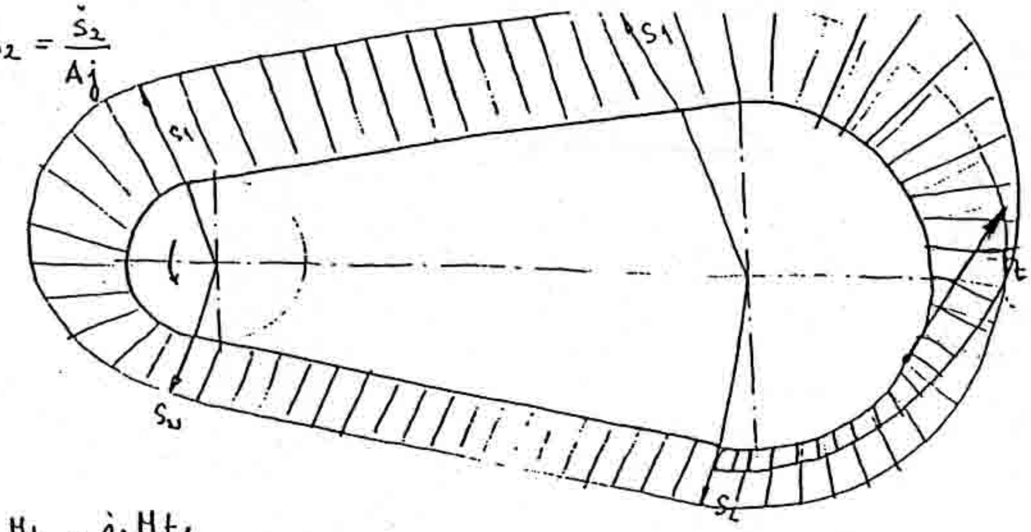
pri mirovanju



$$F_a \cdot a = M_t$$

$$F_a = \sqrt{S_1^2 + S_2^2 - 2 S_1 S_2 \cos 2\gamma}$$

$b_2 = \frac{\dot{s}_2}{A_j}$



$M_{t_2} = i \cdot M_{t_1}$

$M_{t_2} = F_t \cdot \frac{d_2}{2}$

$M_{t_1} = F_t \cdot \frac{d_1}{2}$

$$\frac{S_{1m}}{S_{2m}} = e^{\mu \widehat{\alpha_2}}$$

$P_{00} = M_{t_1} \cdot \omega_1 = P_1$

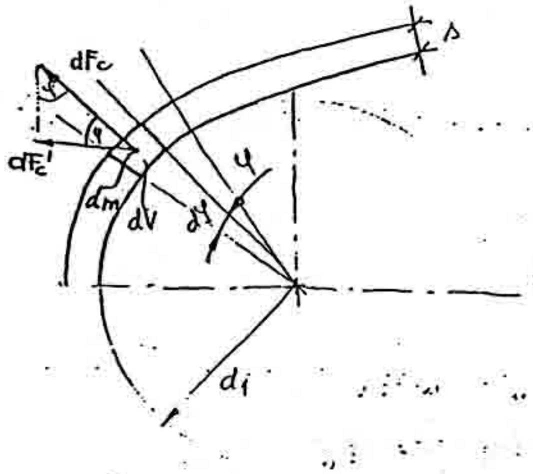
$F_{t_1} \cdot v_1$

ω_1 = konst.

v_1 = velik

d_1 = velik

CENTRIFUGALNA SILA V JERMENU:



$dV = A_j \cdot \frac{d_1}{2} \cdot d\varphi$

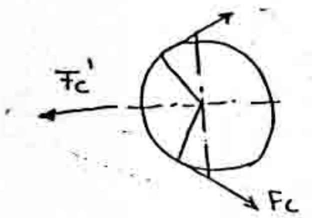
$dm = \rho \cdot dV$

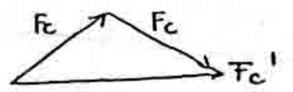
$dF_c = dm \cdot \frac{v^2}{\frac{d_1}{2}}$

$dF_c' = A_j \cdot \rho \cdot v^2 \cdot \sin\varphi \, d\varphi$

$$F_c' = \int_{\delta}^{180-\delta} A_j \cdot \rho \cdot v^2 \cdot \sin\varphi \, d\varphi$$

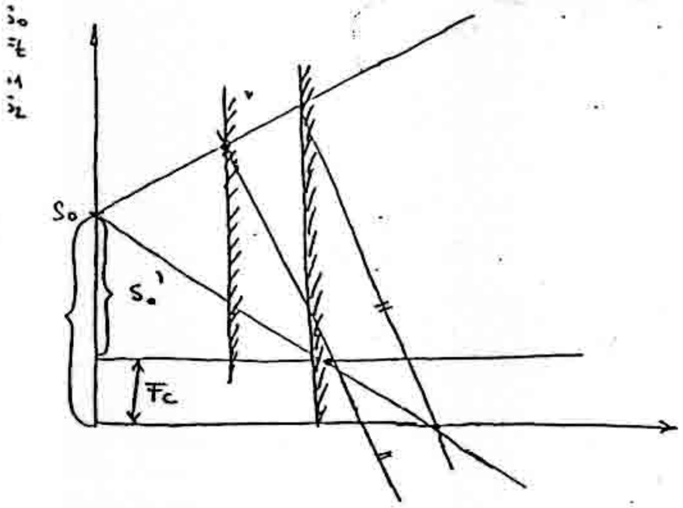
$$\boxed{F_c' = A_j \cdot \rho \cdot v^2 \cdot 2\cos\delta}$$





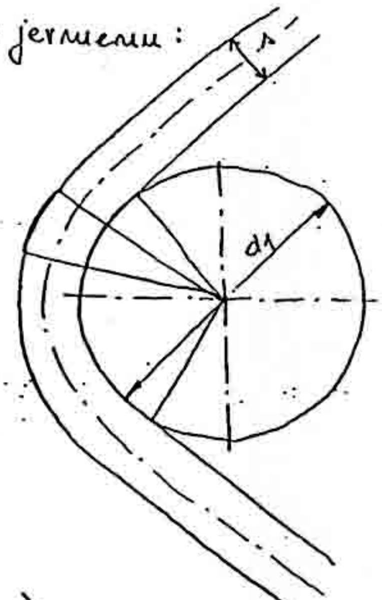
$$\boxed{F_c = A_j \cdot \rho \cdot v^2}$$

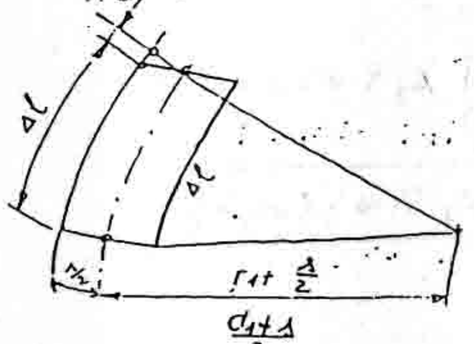
$$\sigma_c = \frac{F_c}{A_j} = \rho \cdot v^2$$



Napetost v jermenu:

a)





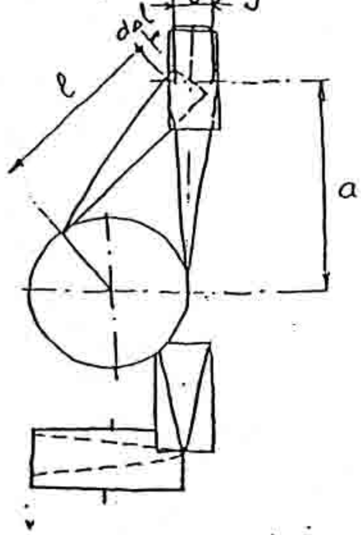
$$\sigma_{up} = \varepsilon_u \cdot E_u$$

$$\sigma_{up} = \frac{d\Delta l}{\Delta l} \cdot E_{up}$$

$$\frac{d\Delta l}{\frac{s}{2}} = \frac{\Delta l}{r_1 + \frac{s}{2}}$$

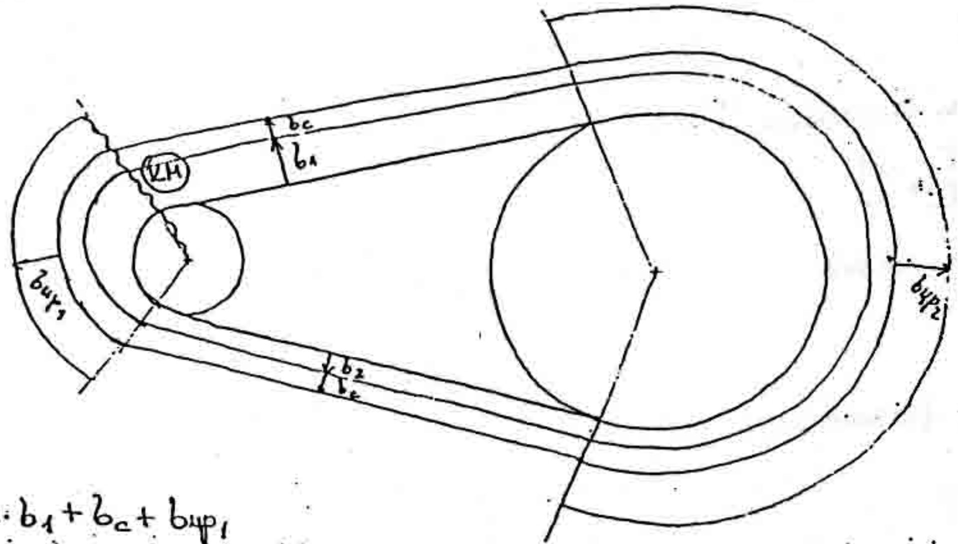
$$\frac{d\Delta l}{\Delta l} = \frac{s}{d_1}$$

... postavljen jermena:



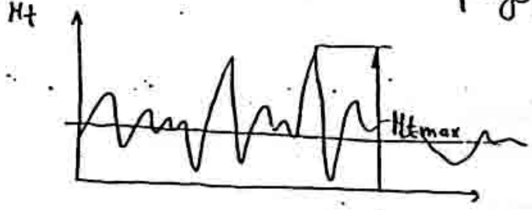
$$b_{up_u} = \left(\frac{h}{\ell}\right)^2 \cdot E_u$$

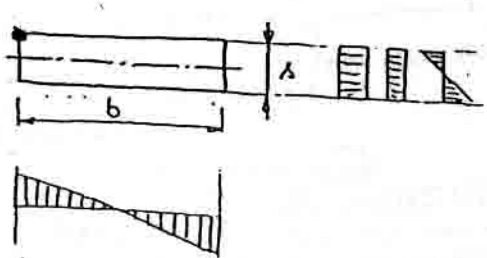
NAPETOSTI V JERMENU:



$b = c \cdot b_1 + b_c + b_{up_1}$

c – faktor obratovalnih pogojev





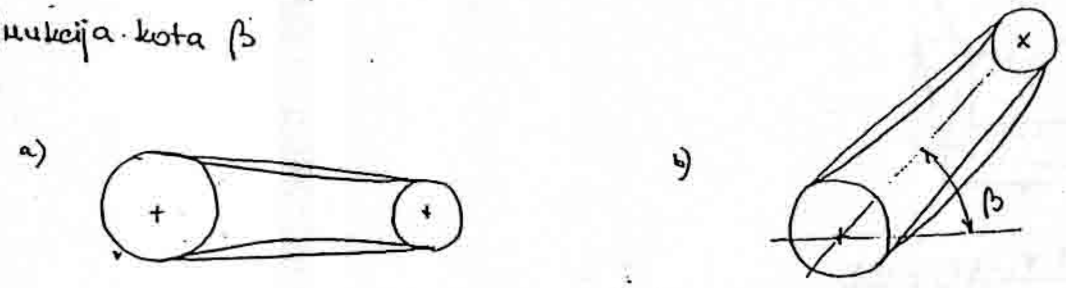
ta napetost
nastopi ob
kližni postavitvi

$\sigma_{max} = c \cdot \sigma_1 + \sigma_c + \sigma_{up_1}$

$c = c_1 \cdot c_2 \cdot c_3$

$c_1 =$

c_2 = funkcija kota β



porazdelitev lastne teže pri dveh različnih postavitvah

$c_3 = f(f_{up})$

f_{up} - upogibna frekvenca

$f_{up} = \frac{z \cdot v}{L} \left[s^{-1}\right]$

z .... število jermenic

$f_{up} \leq f_B$

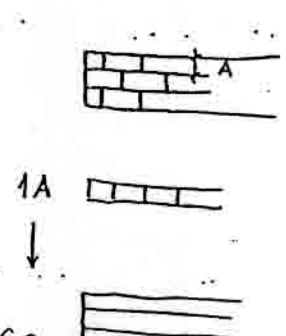
f_B .... mejna frekvenca

$\sigma_{max} \leq \sigma_{dop}$

$\sigma_{dop} = f(\text{materiala})$

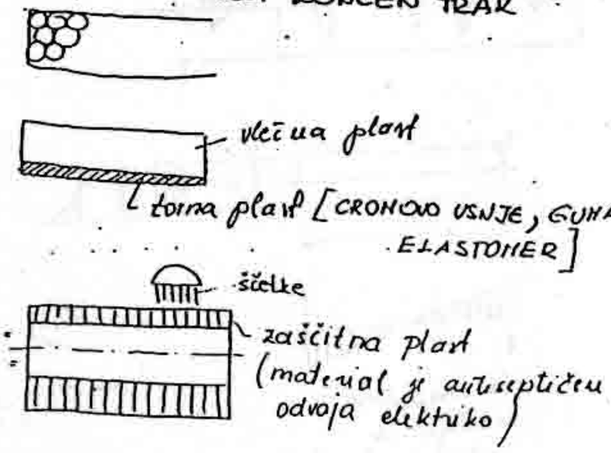
LEČNA PLAST

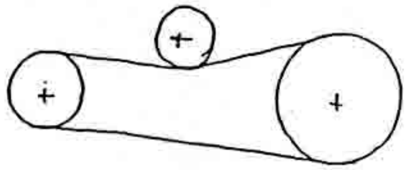
a)



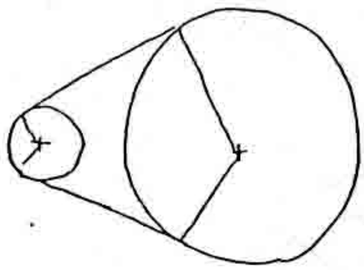
IZDELUJEMO KOT NESKONČEN TRAK

b) IZDELUJEMO KOT KONČEN TRAK





KOLIKO SKUPAJ LAHKO POSTAVIMO JERMENICO:



Omejitve:
- upogibna frekvenca
- torne sile
- α

EXTREMULTUS JERMENI

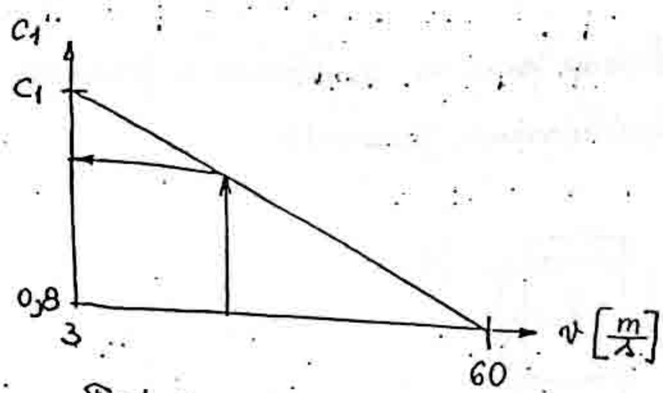
P_m, i, n_1 ✓

$d_1 = $ ✓ (izberem glede na konstrukcijo)

$n_1 = $ ✓ $\Rightarrow \omega_1 = $ ✓

tip jermena določim s pomočjo enačbe:

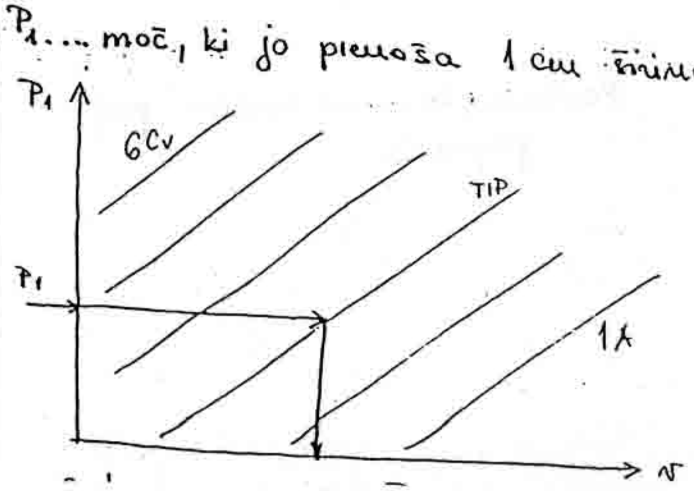
$$\boxed{tip = \frac{d_1 \cdot C_1}{10}}$$



$$v = \frac{\pi \cdot d_1 \cdot n_1}{60}$$

$P_1 = ?$

P_1 .... moč, ki jo prenaša 1 cm širine



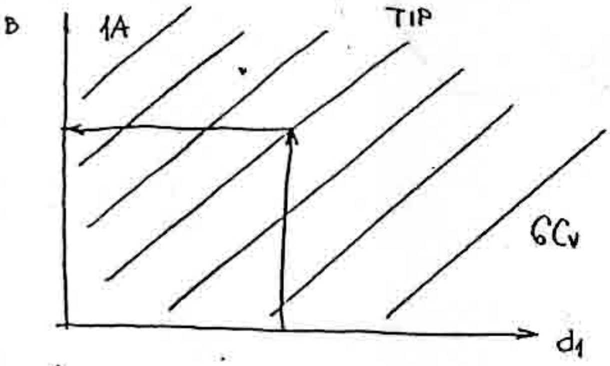
$$b = \frac{P}{P_1} \cdot \frac{C_1 \cdot 10}{C_2} \quad [mm]$$

C_1.... faktor sunkov

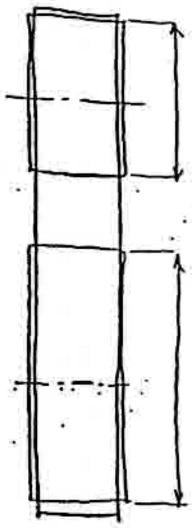
C_2.... funkcija objemnega kota $[\alpha_{min} = 100°]$

$$f_{up} = \frac{z \cdot v}{L}$$

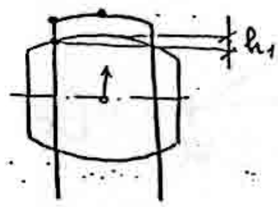
$$f_{up} \leq f_B$$



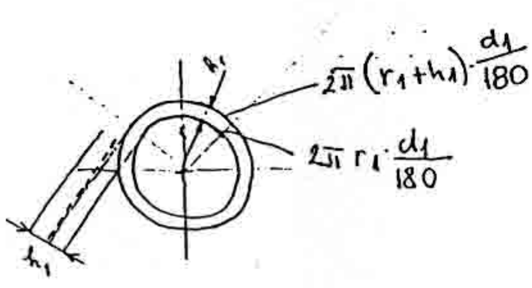
ENJE JERMENA:



Vodenje jermena zagotovimo s pomočjo bombiranih jermenic



h - bombiranost



Konturna točka v sredini prej poprime

$\varepsilon \le \varepsilon_{meji}$

$\left(\frac{h_1}{r_1}\right) \le \varepsilon_{meji}$

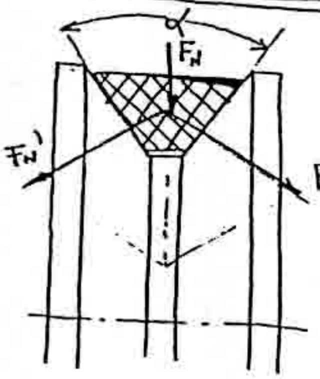
KAJ JE Z BOMBIRANOSTJO DRUGE JERMENICE ?

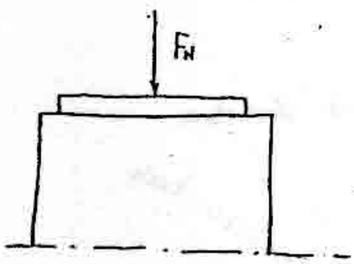
Ponavadi bombirano samo manjšo jermenico. Vendar ne pravč.

STOPNJA IZKORIŠČENOSTI JERMENA:

Razmerje med silo napenjanja in koristno silo

II. KLINASTI JERMEN:





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

$F_N' = \frac{F_N}{2 \cdot \sin\left(\frac{\alpha}{2}\right)}$

$F_{tr} = F_N \cdot \frac{\mu}{\sin\left(\frac{\alpha}{2}\right)} - \mu'$

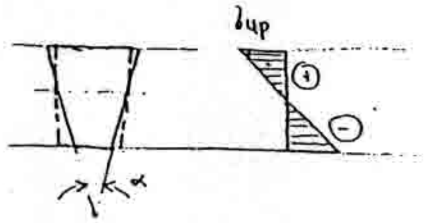
$\boxed{F_{tr} = F_N \cdot \mu'}$

$\boxed{F_{tr} = F_N \cdot \mu}$

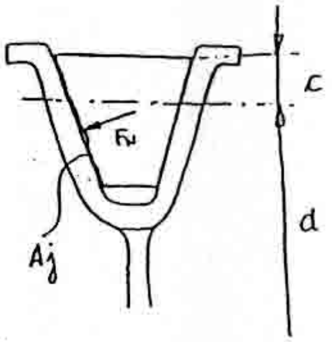
$30 \le \alpha \le 45$

$\alpha_{jerm} = 34°$ (standard)

Širiko jermena pri upogibu:



$\alpha < \alpha_i \quad : \quad \alpha = f(d)$



i... sledeji kinematski prenos (jermen bo tekel brez spodrsavanja)

$$i_t = \frac{d_2}{d_1}$$

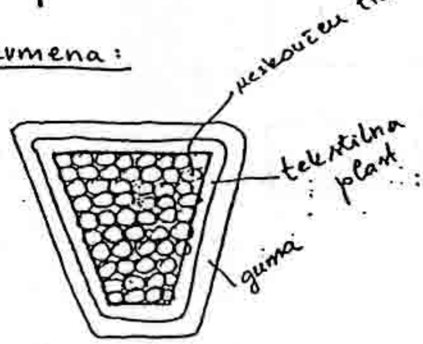
$$i = \frac{d_2}{d_1 \cdot (1-\delta_1)(1-\delta_j)(1-\delta_2)}$$

$$F_{tr}' = F_N \cdot \mu$$

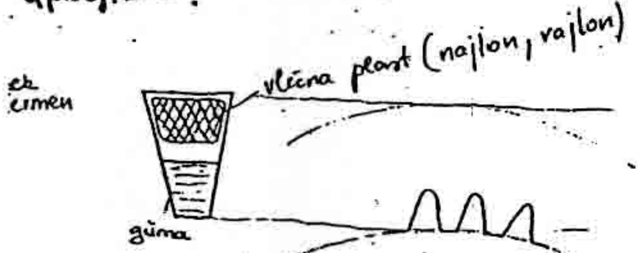
$$F_N \rightarrow p = \frac{F_N}{A_j}$$

$\delta \longrightarrow p$ (prevelik) $\rightarrow$ obraba
odrzavanje

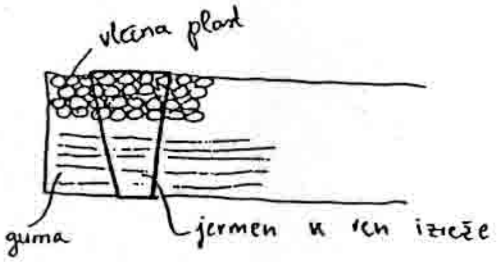
<u>adba Jermena:</u>

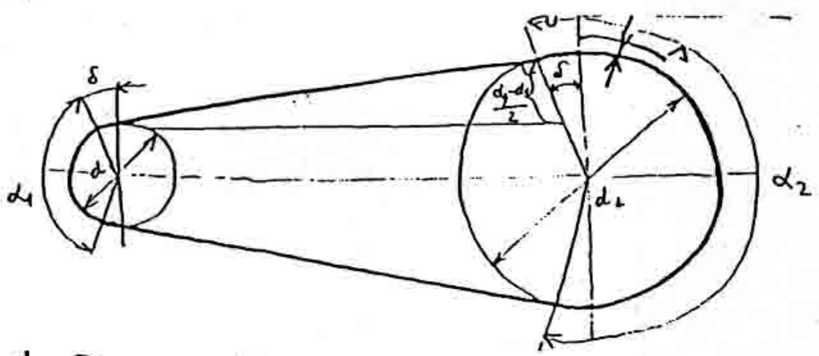


upogib = ?



jermen zarežemo → odprava deformacij





$$L_n = \frac{d_1}{2}\cdot\hat{\alpha}_1 + \cancel{2}\cdot\frac{d_2-d_1}{\cancel{2}\cdot tg\,\delta} + \frac{d_2}{2}\cdot\hat{\alpha}_2$$

$$L_n = \frac{d_1}{2}\cdot\hat{\alpha}_1 + \frac{d_2-d_1}{tg\,\delta} + \frac{d_2}{2}\cdot\hat{\alpha}_2$$

$$\hat{\alpha}_1 = \pi - 2\hat{\delta}$$

$$\hat{\alpha}_2 = \pi + 2\hat{\delta}$$

$$L_n = \frac{1}{2}\cdot d_1(\pi - 2\hat{\delta}) + \frac{d_2-d_1}{tg\,\delta} + \frac{1}{2}d_2(\pi + 2\hat{\delta})$$

$$L_n = \frac{1}{2}d_1\cdot\pi - d_1\cdot\hat{\delta} + \frac{d_2-d_1}{tg\,\delta} + \frac{1}{2}d_2\pi + d_2\cdot\hat{\delta}$$

$$\boxed{L_n = \left[\frac{\pi}{2}(d_1+d_2) + \hat{\delta}(d_2-d_1)\right] + \frac{d_2-d_1}{tg\,\delta}}$$

na zunanjem vlaknu:

$$L_z = \left(\frac{d_1}{2}+s\right)\cdot\hat{\alpha}_1 + \cancel{2}\cdot\left(\frac{d_2-d_1+\cancel{2s}}{\cancel{2}\cdot tg\,\delta}\right) + \left(\frac{d_2}{2}+s\right)\cdot\hat{\alpha}_2$$

$$L_z = \left(\frac{d_1}{2}+s\right)\cdot\hat{\alpha}_1 + \left(\frac{d_2-d_1+\cancel{2s}}{tg\,\delta}\right) + \left(\frac{d_2}{2}+s\right)\cdot\hat{\alpha}_2$$

$$\hat{\alpha}_1 = \pi - 2\hat{\delta}$$

$$\hat{\alpha}_2 = \pi + 2\hat{\delta}$$

$$L_z = \left(\frac{d_1}{2}+s\right)(\pi - 2\hat{\delta}) + \left(\frac{d_2-d_1+\cancel{2s}}{tg\,\delta}\right) + \left(\frac{d_2}{2}+s\right)(\pi + 2\hat{\delta})$$

$$L_z = \frac{d_1}{2}\pi - d_1\cdot\hat{\delta} + \pi\cdot s - \cancel{2s\hat{\delta}} + \frac{d_2-d_1+\cancel{2s}}{tg\,\delta} + \frac{d_2}{2}\cdot\pi + s\pi + d_2\cdot\hat{\delta} + \cancel{2s\hat{\delta}}$$

$$L_z = \frac{d_1}{2}\pi + \frac{d_2}{2}\pi - d_1\hat{\delta} + d_2\hat{\delta} + 2\pi s + \frac{d_2-d_1+\cancel{2s}}{tg\,\delta}$$

$$\boxed{L_z = \frac{1}{2}\pi(d_1+d_2) + \hat{\delta}(d_2-d_1) + \frac{d_2-d_1+\cancel{2s}}{tg\,\delta} + 2\pi s}$$

$$\boxed{L_z = L_n + 2\pi\cdot s}$$

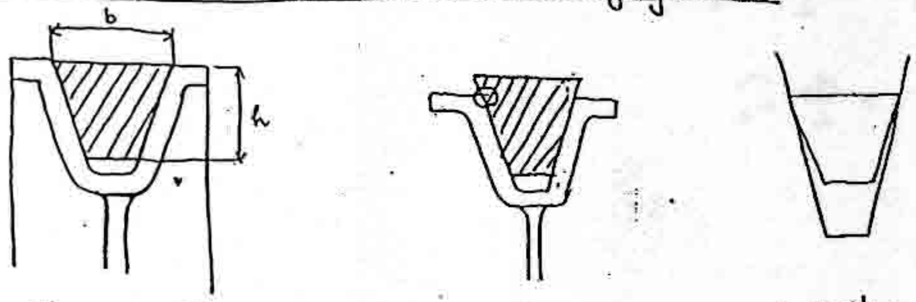
$$\frac{S_1}{S_2} = e^{\mu' \alpha}$$

$$S_1 - S_2 = F_t$$

$$S_1 + S_2 = F_a$$

$$F_a = (2 \div 3) F_t$$

vilna in nepravilna namestitev klinastega jermena:

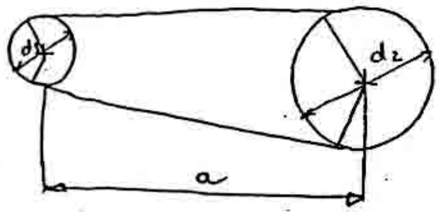


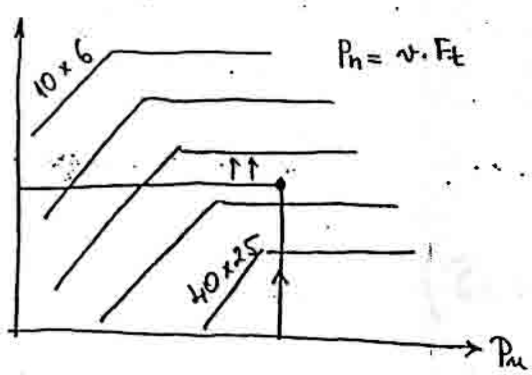
pravilna namestitev nepravilna nepravilna

ienzioniranje klinastega jermena:

n, n_1, i

likovati jermenski prenos





$P_n = v \cdot F_t$

h	×	b
10	×	6
⋮		⋮
40	×	25

izbereš zmeraj zgornji jermen (bolj gibki)

$v_1 \doteq 25 \frac{m}{s}$

$v_1 \to 40 \frac{m}{s}$

$v_1 \to 20 \frac{m}{s}$ (politi jermen)

P_{nj} (odčitaš iz tabel)

$$= \frac{P_n}{P_{nj} \frac{c_1 \cdot c_3}{c_2}}$$

j... število jermenov

$c_1 = c_1 (\alpha_j)$

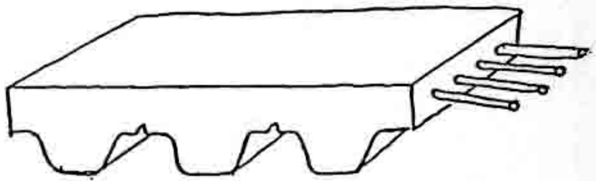
$c_2 = c_2 \left(\frac{Ht_{max}}{Ht} \right)$

$c_3 = c_3 \left(\frac{d_{SR1}}{d_{SR1\,min}} \right)$

c_1, c_2, c_3 .... faktorji, ki nam povedo, koliko se obratovalne razmere razlikujejo od razmer v laboratoriju.

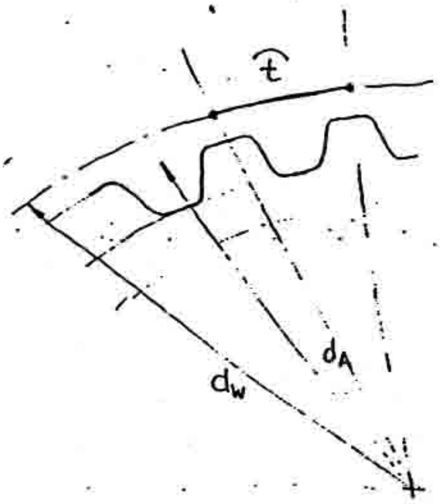
PRENOS VRTILNEGA GIBANJA Z OBLIKO

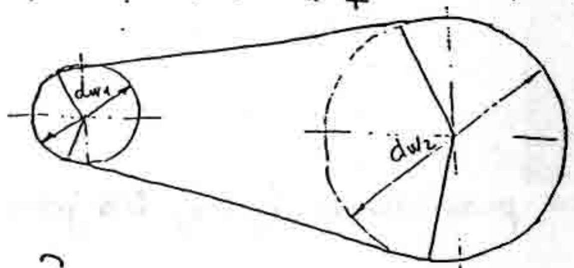
I. PLOŠČATI ZOBATI JERMEN:



izdelan kot neskončen trak (CABLE CORD)

Nosi le prvih pet zob po obodu





$z_1 \cdot \hat{t} = \pi \cdot d_{w1}$

$z_2 \cdot \hat{t} = \pi \cdot d_{w2}$

v

$v_{w1} \neq v_{w1}$

zaradi raztegovanja jermena

$$\frac{\pi \cdot dw_1 \cdot n_1}{60} = \frac{\pi \cdot dw_2 \cdot n_2}{60}$$

$$i_t = \frac{n_1}{n_2} = \frac{dw_2}{dw_1} = \frac{z_2}{z_1}$$

$$\boxed{i = \frac{n_1}{n_2} = \frac{dw_2}{dw_1 \cdot (1 - \delta_j)}}$$

ok ko dosežem le določene prestave ??

$\delta_j = \delta_j (Ht)$
$i = i (Ht)$
$\delta_j \doteq 2\%$ [za ploščati jermen]

Jermen mora biti narejen s končnim številom zob

$L_w = ?$

$$\boxed{L_w = t \cdot z_j}$$

$z_j \in \mathbb{N}$

$L_w^z \neq L_w$
$\downarrow$
$L_w^z \to a$

} pri preračunu grem nazaj in izračunam medosno razdaljo.

PRERAČUN:

$P_{nj} \left(\frac{kW}{1cm}\right)$ ... tabeliran

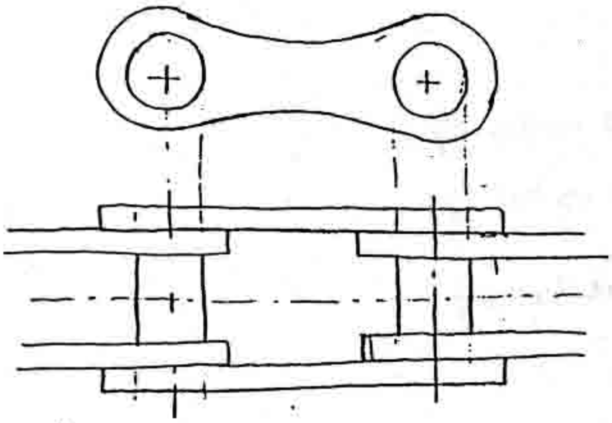
$$b = \frac{P_n}{P_{nj} \cdot \frac{c_1 \cdot c_3}{c_2}}$$

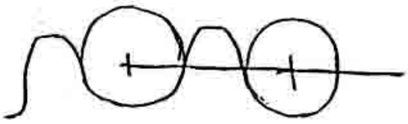
aterial jermenice mora biti odporen proti obrabi. (jeklo, lito jeklo, egirano jeklo)

luminij ne ker se prej obrabi kot guma

ožen prenos moči do 250 kW.

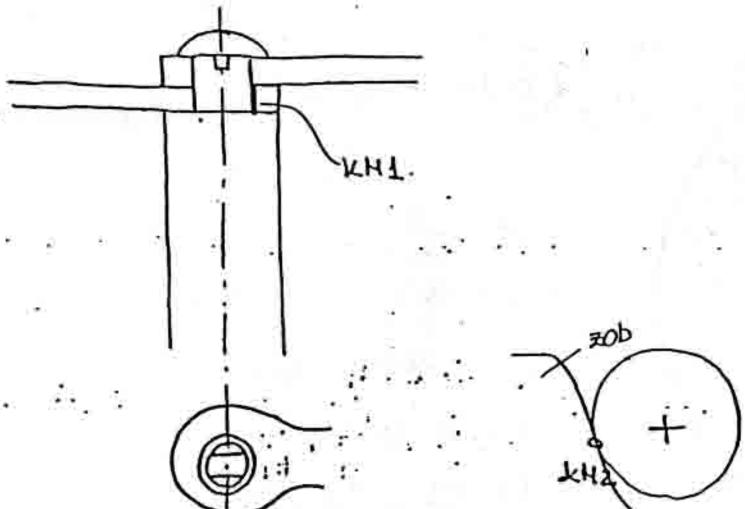
II. VERIZNA GONILA





delitev pri verigi je "h"

Sile se prenašajo med lamelami, ter med lamelami in sorniki.



KH 1 - mazanje
KH 2. - puša na puši.

Material:

LAMELE : Č.0645
SORNIK : Č.0545

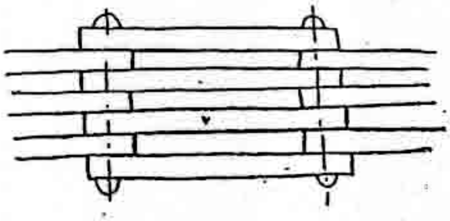
Za visokovredne verige:

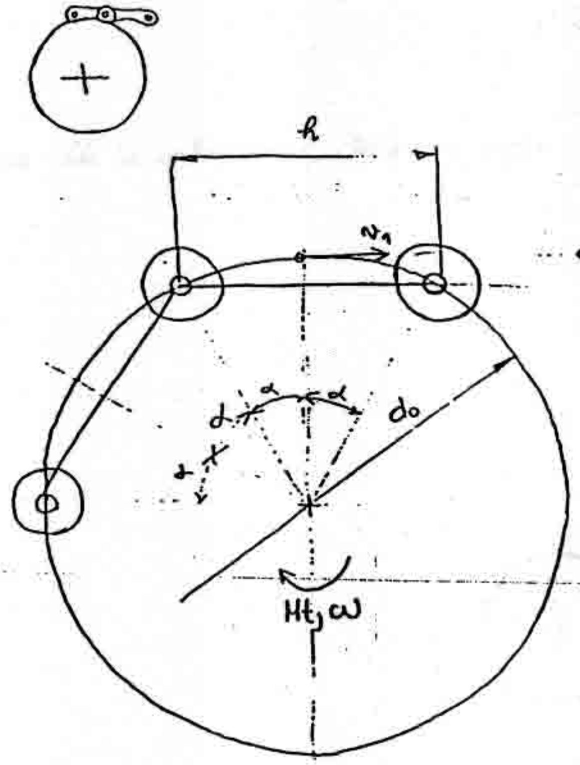
LAMELE: Vzmetno jeklo legirano s Si
SORNIK : jeklo za poboljšanje

...čajna veriga : $v \to 3 \frac{m}{s}$
...riga s pušami : $v \to 4 \frac{m}{s}$
...riga s kotalko :

- standardna $v \to 20 \frac{m}{s}$
- visokovredna $v \to 40 \frac{m}{s}$

REMENSKA VERIGA: (povezanih več lamel)





$v_1 = v_2$ (ni raztegovanja)

$$d_o = \frac{h}{\sin \alpha}$$

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

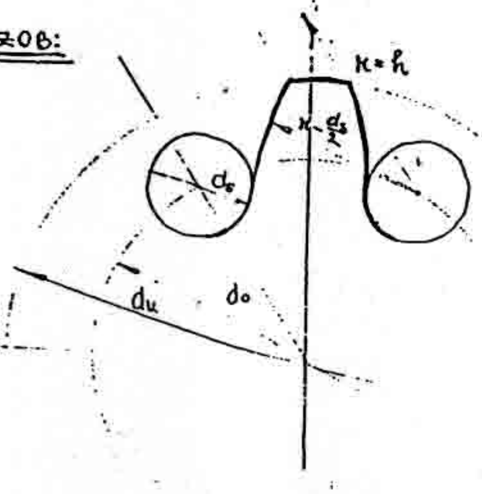
z.... število zob

$$v_1 = \pi \cdot d_o \cdot n_1$$

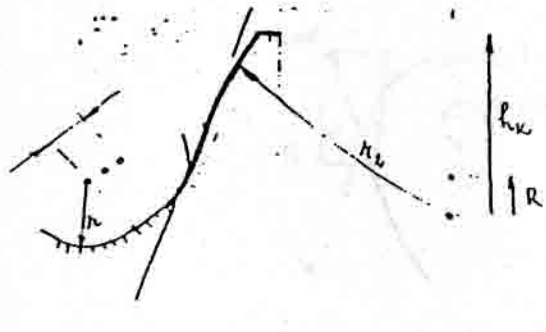
$$i = \frac{n_1}{n_2} = \frac{d_{o2}}{d_{o1}} = \frac{z_2}{z_1}$$

Med vlečenjem pride do POLIGONSKEGA EFEKTA, ker se ena stran vrti enakomerno, drugo pa se zaganja zato i ni konstantno ni dobimo nihanje.

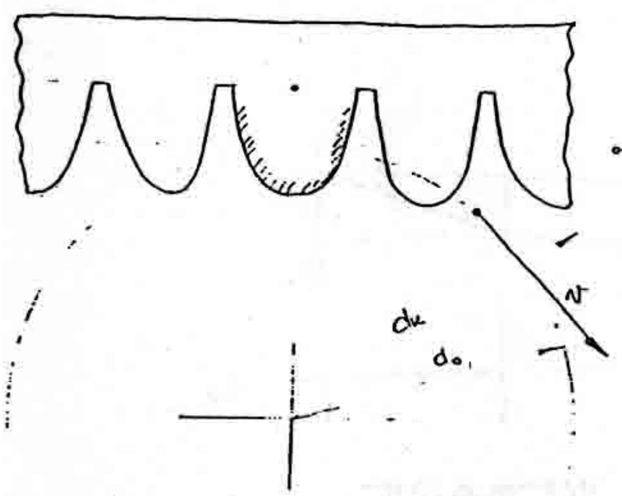
OBLIKA ZOB:



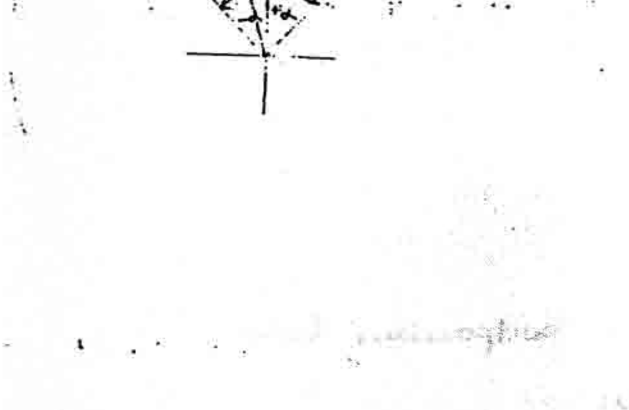
d_u - temenski radij



Orodje za izdelavo zob so v obliki letve:



KINEMATIKA OZOBJA:



$$\varphi = \omega \cdot t$$

$$s_x = \frac{d_o}{2} \cdot \sin(\omega t)$$

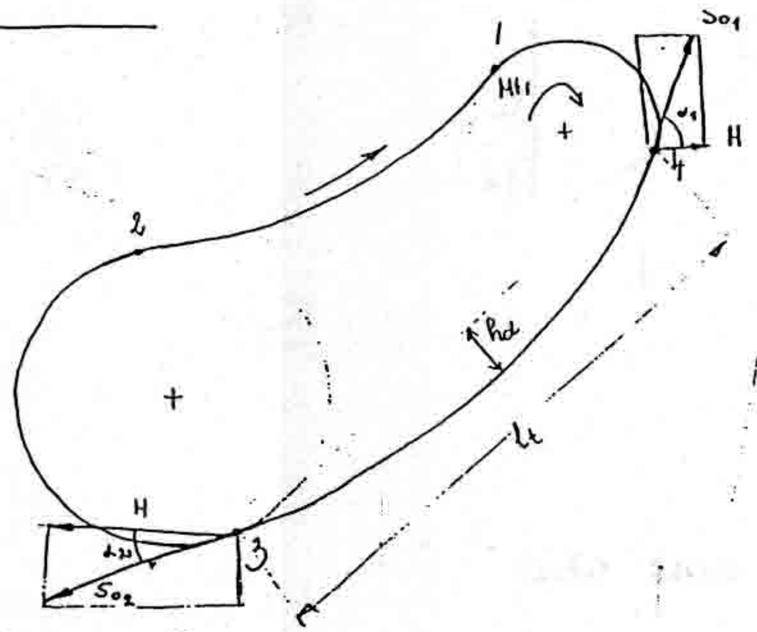
$$s_y = \frac{d_o}{2} \cdot \left(\cos\alpha - \cos(\omega t\right.$$

$$v_x = \dot{s}_x = \frac{d_o}{2} \cdot \omega \cdot \cos(\omega t)$$

$$v_y = \dot{s}_y = -\frac{d_o}{2} \cdot \omega \cdot \sin(\omega t)$$

$$a_x = -\frac{d_o}{2} \cdot \omega^2 \cdot \sin(\omega t)$$

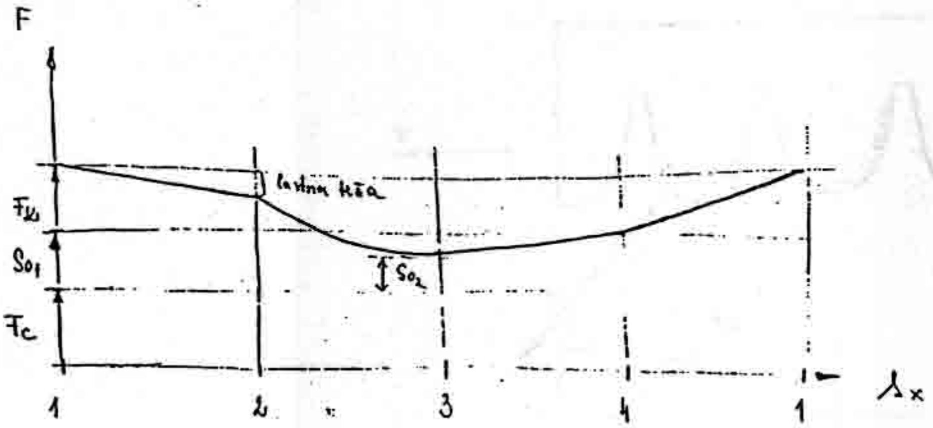
$$a_y = -\frac{d_o}{2} \cdot \omega^2 \cdot \cos(\omega t)$$



$$H = \frac{q \cdot l_T^2}{8 \cdot h_d}$$

$$S_{o1} = \frac{H}{\cos\alpha_1}$$

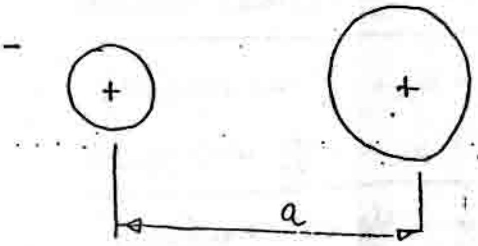
$$S_{o2} = \frac{H}{\cos\alpha_2}$$



IMENZIONIRANJE VERIGE:

jabaritne dimenzije verige
začasna izbira verige
kontrola verige

) M_1, i



$_k = z_k \cdot h$

$. = (20 \div 80) \cdot h$

$. > 2,5\,m$ → potrebno podpitje s podpornimi kolesi

$> 7\,\frac{m}{s}$ da bo učinkovit prenos

$< 15\,\frac{m}{s}$ za normalne verige

$i \leq 7$ se da zagotoviti

$i \to 10$ za precizne verige

$d_{01} = d_{01}(h, z_1)$

$= d_{01}(n)$

$z_1 = 19$

2.) Začasna izbira verige

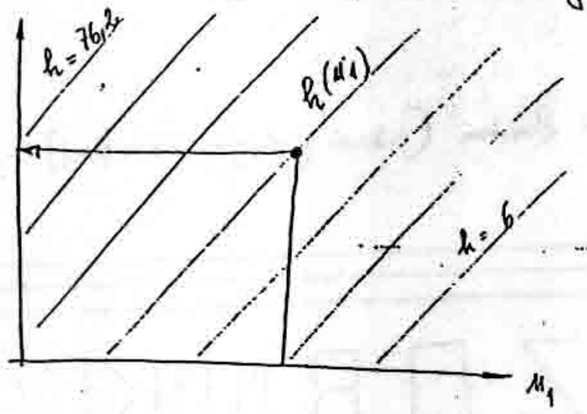
P_D ... moč, ki jo prenaša idealno gonilo, na katerega je namotirana veriga

$z_1 = 19$

$i = 3$

$a = 40 \cdot h$

$L_h = 10000\ h$



$P = P_D \cdot c$

$C = k \cdot C_A \cdot C_F \cdot C_K \cdot C_L \cdot C_S \cdot C_W$

k ... faktor sunkov $= f\left(\left(\frac{M_{t\,max}}{M_{t\,nazivni}}\right), i, z_1\right)$

C_A ... faktor medosne razdalje

C_F ... -"- oblike verige

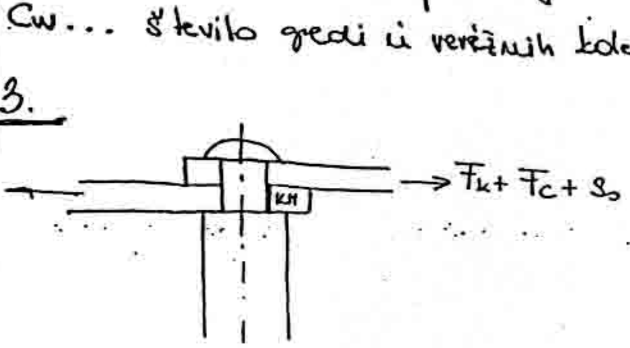
C_K ... število členov verige

C_L ... faktor življenske dobe

C_S ... faktor mazanja verige

C_W ... število gredi in verižnih koles preko katerih veriga teče

3.



$$p = \frac{F_k + F_c + S_o}{A}$$

$p \in p_{dop}$

p_o ... dopustni tlak v idealnih razmerah

C_R ... faktor velikosti dorabe

C_{ST} ... faktor sunkov

$$p_{dop} = p_o \cdot C_R \cdot C_L \cdot C_{ST} \cdot C_W \cdot C_k \cdot C_s$$

INA PORUŠITEV

$$S_B = \frac{F_B}{F_{CEL}}$$

$F_{CEL} = F_k + F_c + S_{01}$

F_B... tabelirano

$S_B > 7$

) DINAMIČNA ~~NOSILNOST~~ VARNOST

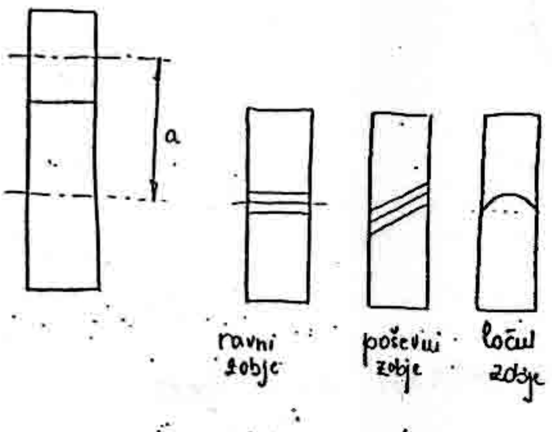
$$S_D = \frac{F_B}{Y \cdot F_{CEL}}$$

Y.... dinamični faktor (skrit poligonski efekt)

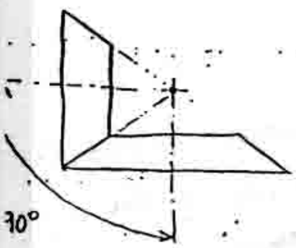
$S_D > 5$

ZOBNIKI

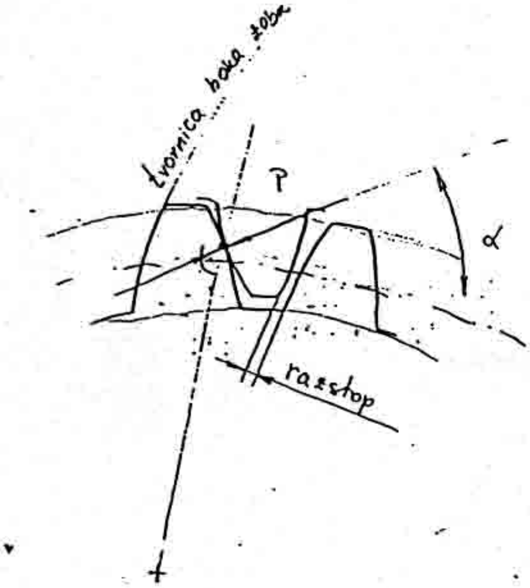
renos z obliko.



OŽČAST ZOBNIK:



Vse tvornice se sekajo v eni točki



P... ubirna točka

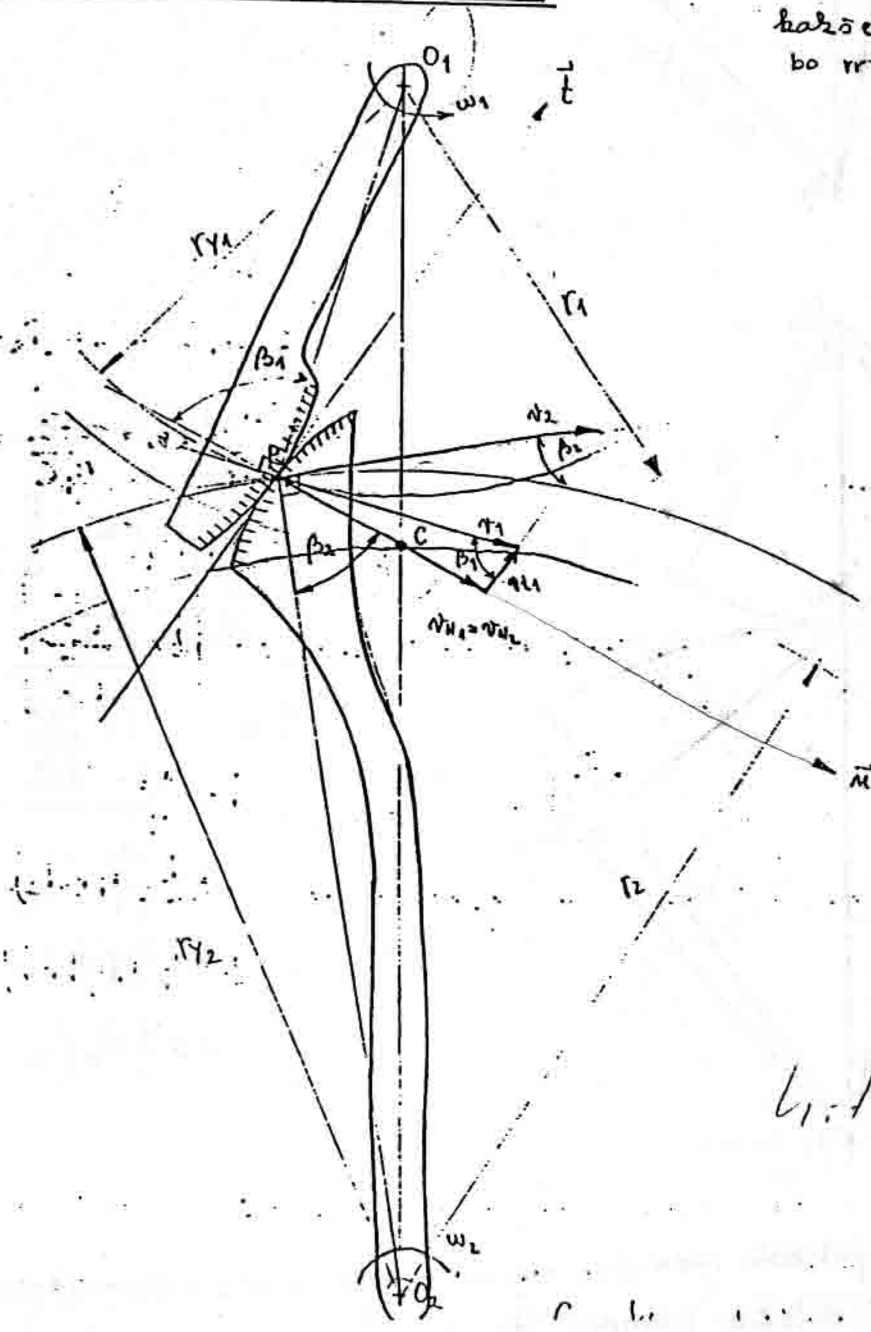
α.... ubirni kot

če slučajno ni izraženo z modul

$d_0 = m \cdot z$

$t_0 = \pi \cdot m$

ZAKON OZOBJA:



Iščemo zakonitost, ki bo povedala kakšen mora biti bok zoba da bo vrtenje enakomerno.

$$\boxed{i = \frac{\omega_1}{\omega_2}} = konst.$$

$\omega_1 = konst \Rightarrow \omega_2 = ko$

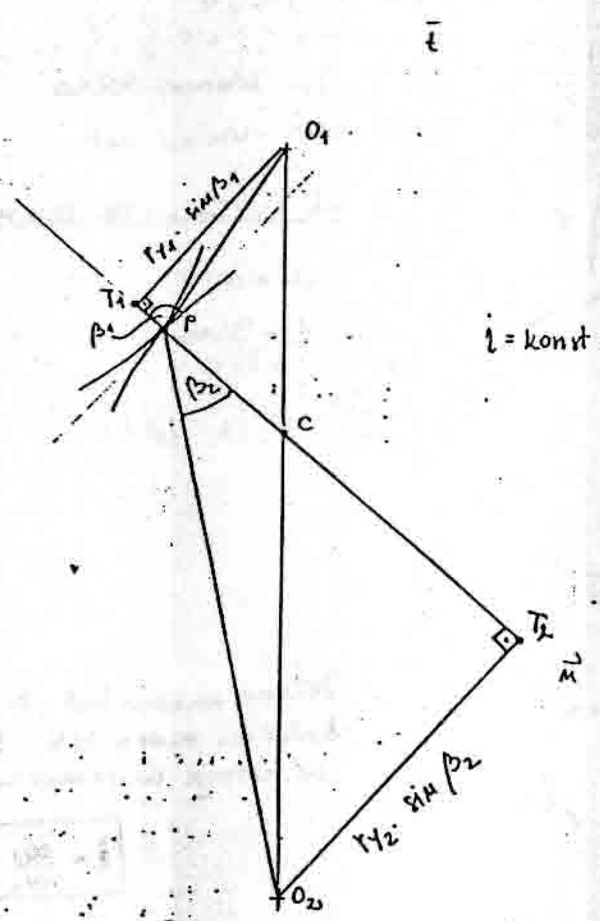
$v_1 = r_{y_1} \cdot \omega_1$

$v_2 = r_{y_2} \cdot \omega_2$

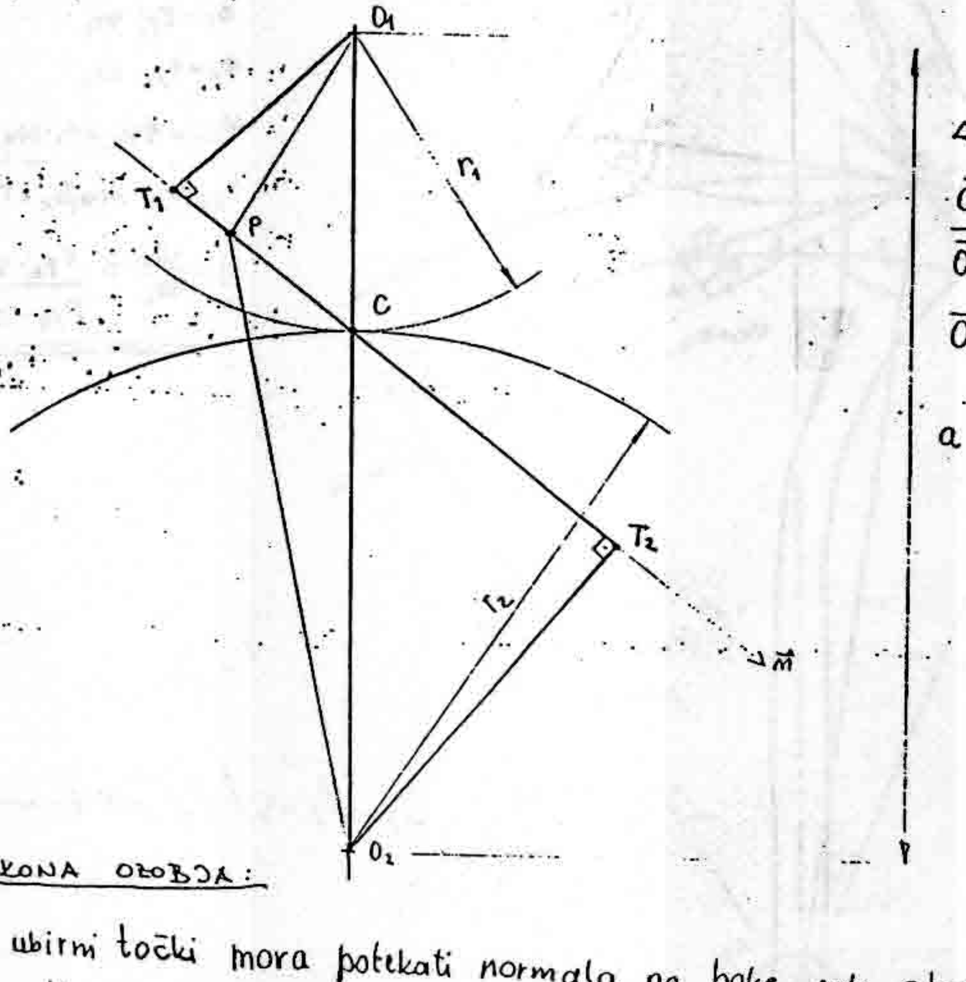
$v_{N_1} = v_{N_2} = v_1 \cdot \sin\beta_1 = v_2 \cdot s$

$r_{y_1} \cdot \omega_1 \cdot \sin\beta_1 = r_{y_2} \cdot \omega_2 \cdot s$

$$i = \frac{\omega_1}{\omega_2} = \frac{r_{y_2} \cdot \sin\beta_2}{r_{y_1} \cdot \sin\beta_1}$$



$$i = \text{konst} = \frac{\omega_1}{\omega_2} = \frac{r_{y2}\cdot\sin\beta_2}{r_{y1}\cdot\sin\beta_1} = \frac{\overline{O_2T_2}}{\overline{O_1T_1}}$$



$$\Delta O_1T_1C \propto \Delta O_2T_2C$$

$$\frac{\overline{O_2T_2}}{\overline{O_1T_1}} = k = \frac{\overline{O_2C}}{\overline{O_1C}} = i$$

$$\overline{O_2C} + \overline{O_1C} = a$$

$$\boxed{i = \frac{\overline{O_2C}}{\overline{O_1C}}}$$

$$i = \frac{d_2}{d_1}$$

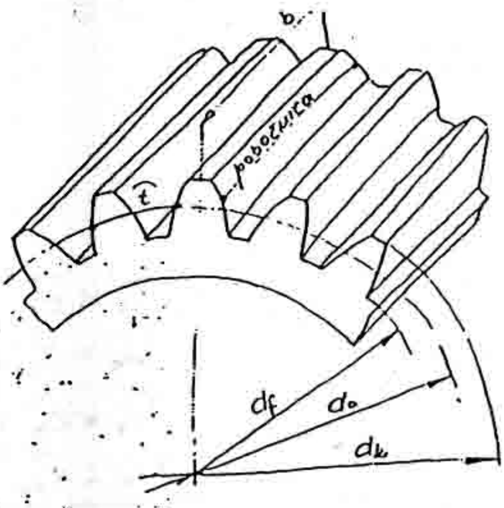
$$a = \frac{1}{2}(d_1 + d_2)$$

$$a = \frac{1}{2}d_1(1+i)$$

F. ZAKONA OZOBJA:

Vsaki ubirni točki mora potekati normala na boke zob skoz kinematski ol "C". Kinematski pol določa premera d_1 in d_2

OZNAČBE NA ZOBNIKU:



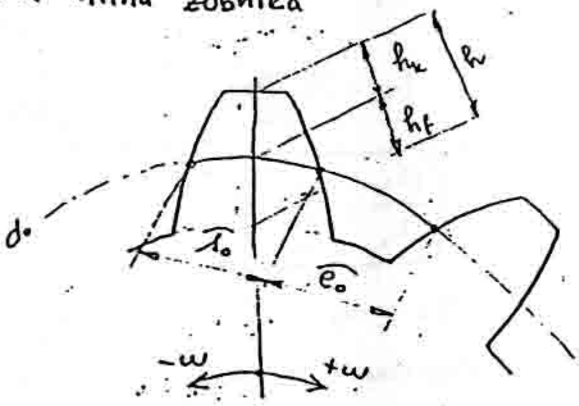
d_f... vznožni krog

d_o... razdelni krog

d_k.... glavični krog

$\hat{t}$... delitev

b.... širina zobnika



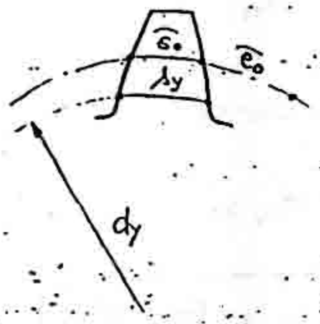
$\hat{s}_o$... debelina zoba na razdelnem krogu

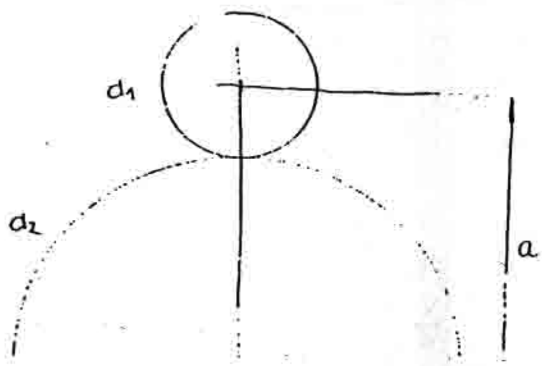
e_o... vrzel zoba na razdelnem krogu

h_k... višina glave zoba

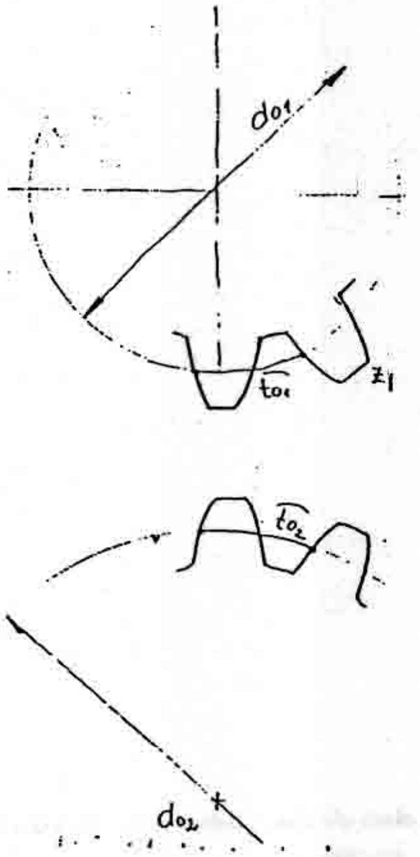
h_f... višina korena zoba

$\hat{t}_o = \hat{s}_o + \hat{e}_o$



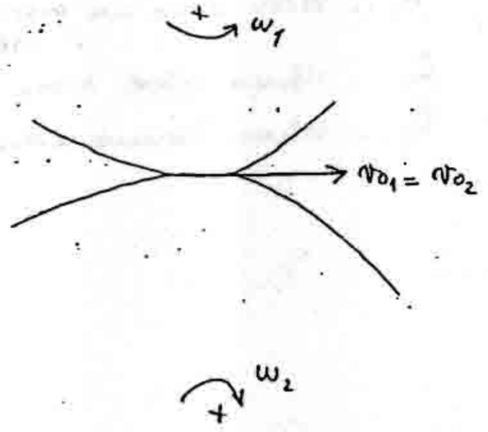


a.... najkrajša razdalja med osmi (medosna razdalja)



$$\widehat{s_{o2}} < \widehat{e_{o1}}$$
$$\widehat{t_{o1}} = \widehat{e_{o1}} + \widehat{s_{o1}}$$
$$\widehat{t_{o2}} = \widehat{e_{o2}} + \widehat{s_{o2}}$$
$$\widehat{s_{o1}} < \widehat{e_{o2}}$$
$$\widehat{t_{o1}} = \widehat{t_{o2}} = t_o$$

$$t_{o1} = \frac{\pi \cdot d_{o1}}{z_1}$$
$$t_{o2} = \frac{\pi \cdot d_{o2}}{z_2}$$
$$\boxed{\frac{d_{o1}}{d_{o2}} = \frac{z_1}{z_2}}$$



$$v_{o1} = v_{o2}$$
$$\omega_1 \cdot d_{o1} = \omega_2 \cdot d_{o2}$$
$$\boxed{i = \frac{\omega_1}{\omega_2}}$$ definicija prestave

$$i = \frac{d_{o2}}{d_{o1}} = \frac{z_2}{z_1}$$

$$\frac{t_o}{\pi} = d_{o1} \cdot z_1$$
$$\frac{t_o}{\pi} = d_{o2} \cdot z_2$$

m.... modul

$$\boxed{\frac{t_o}{\pi} = m = \frac{d_{o1}}{z_1} = \frac{d_{o2}}{z_2}}$$

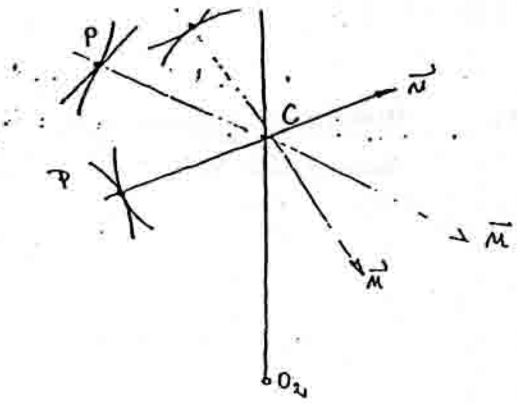
odul je standardiziran z R40

tandardni moduli so razdeljeni v tri razrede

razred: povsem uporabljiv

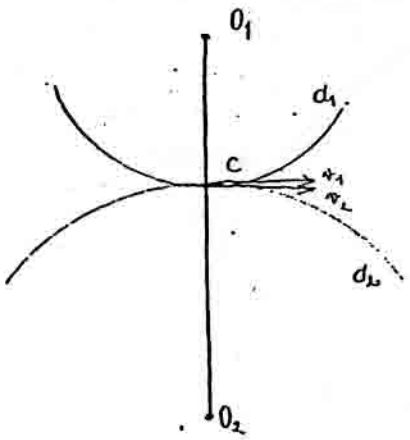
" : uporaba, či so upravičeni razlogi

razred: v izjemnih primerih



Če leži P pod C je treba spremeniti smer vrtenja

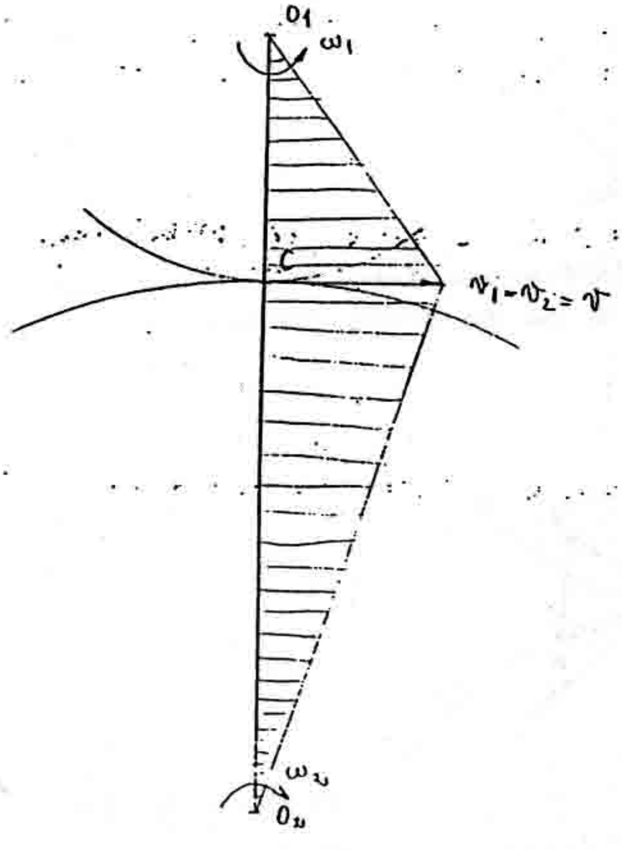
Hitrosti bokov v ubirni točki v smeri tangente "l" sta različni, kar pomeni da boki v ubirni točki v smeri skupne tangente "l" drsijo + kotalijo. V smeri skupne tangente "t" sta hitrosti enaki. nič v kinematskem polu "C" tako se gibanje med boki zob prenaša s kotaljenjem



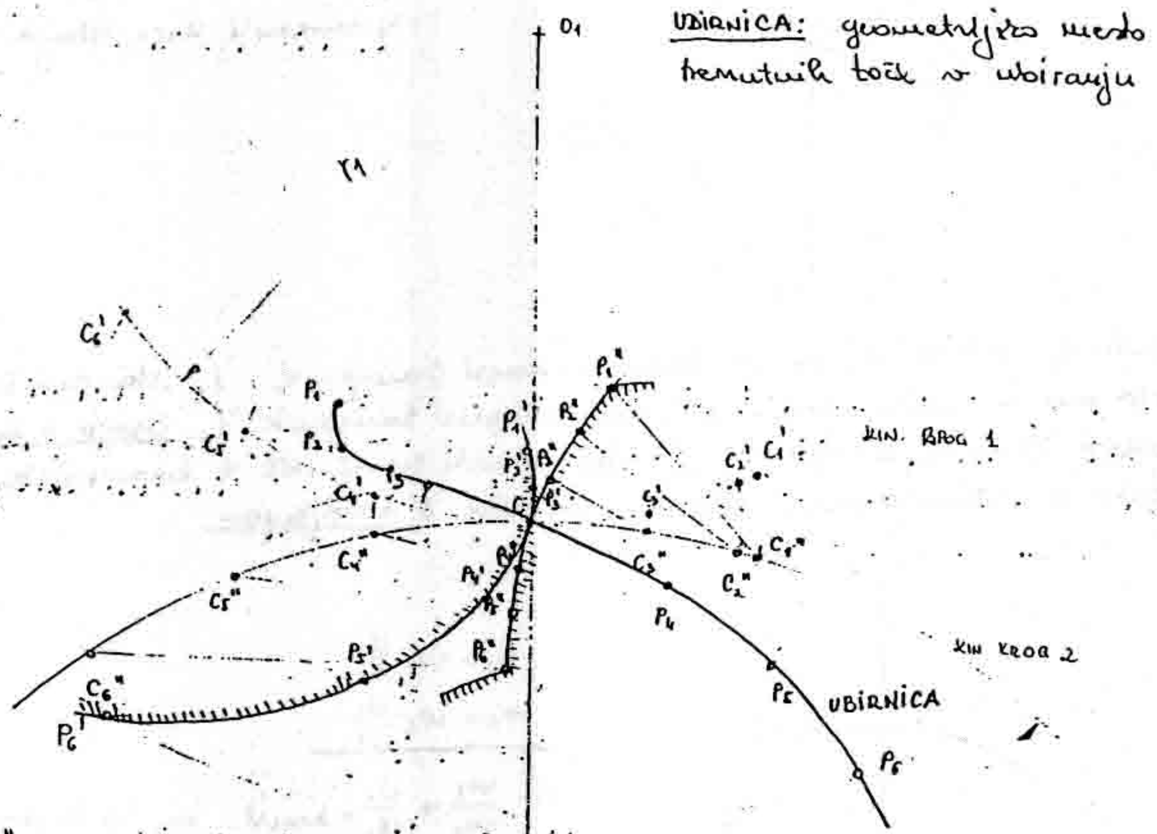
$$v_1 = \omega_1 \cdot \frac{d_1}{2}$$

$$v_2 = \omega_2 \cdot \frac{d_2}{2}$$

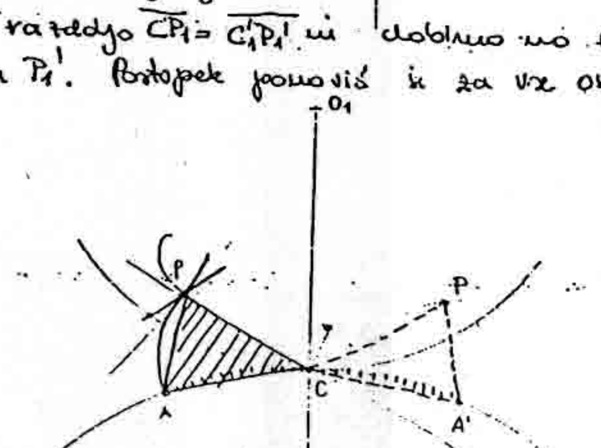
$i = \frac{\omega_1}{\omega_2} = \frac{d_2}{d_1} =$ konst. in to samo takrat ko je $\boxed{v_1 = v_2}$



UBIRNICA: geometrijsko mesto trenutnih točk v ubiranju

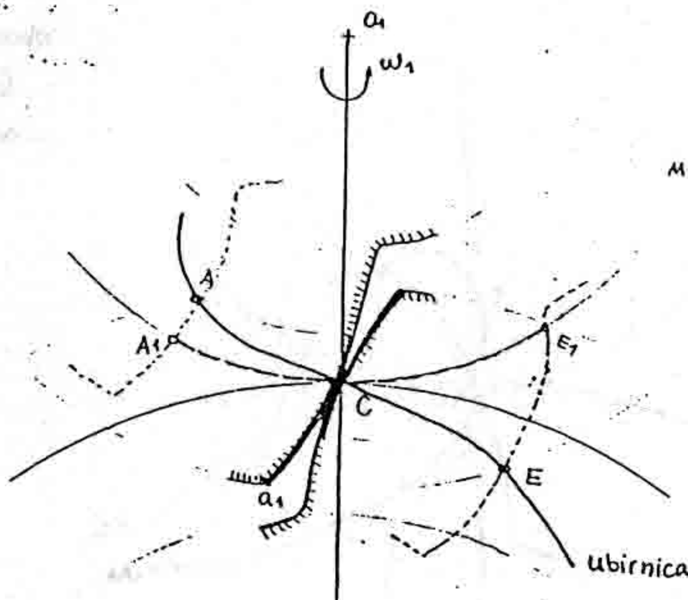


…ri točko P_1'' potegnemo normalo na bok …ba ter z njo dobimo točko C_1'' na …nematskem krogu 2. Ko se zavrti kolo 2 …lok $C_1''C$ potuje točka P_1'' po krogu z …dijem $\overline{O_2P_1''}$. Z razdaljo $\overline{P_1''C_1''} = \overline{P_1C}$ je …ka P_1 določena. Pri povratnem vrtenju … potuje točka P_1 po krogu z radijem $\overline{O_1P_1}$, točka C pa pride na prvem kinematskem krogu v lego C_1'. Ker med …nematskima krogoma ni drsenja je $\widehat{CC_1''} = \widehat{CC_1'}$ … točke C_1' nanesemo razdaljo $\overline{CP_1} = \overline{C_1'P_1'}$ in dobimo na loku O_1P_1 točko na …ravnem boku zoba P_1'. Postopek ponoviš … za vse ostale točke.



Imana je ubirnica normala na bok zoba gre v točko C

DOLŽINA:



Marisana v srednji legi

A - začetek obiranju
E - konec obiranja
$\widehat{AE}$ - dolžina ubirnica $(\widehat{ACE})$
A_1E_1 - ubirni lok $(\widehat{A_1CE_1})$
$\widehat{AA_1a_1}$ - obrabna dolžina

$\widehat{E_1} > \widehat{t}$

.qi zob začne ubirati, ko bo prvi ši
biral

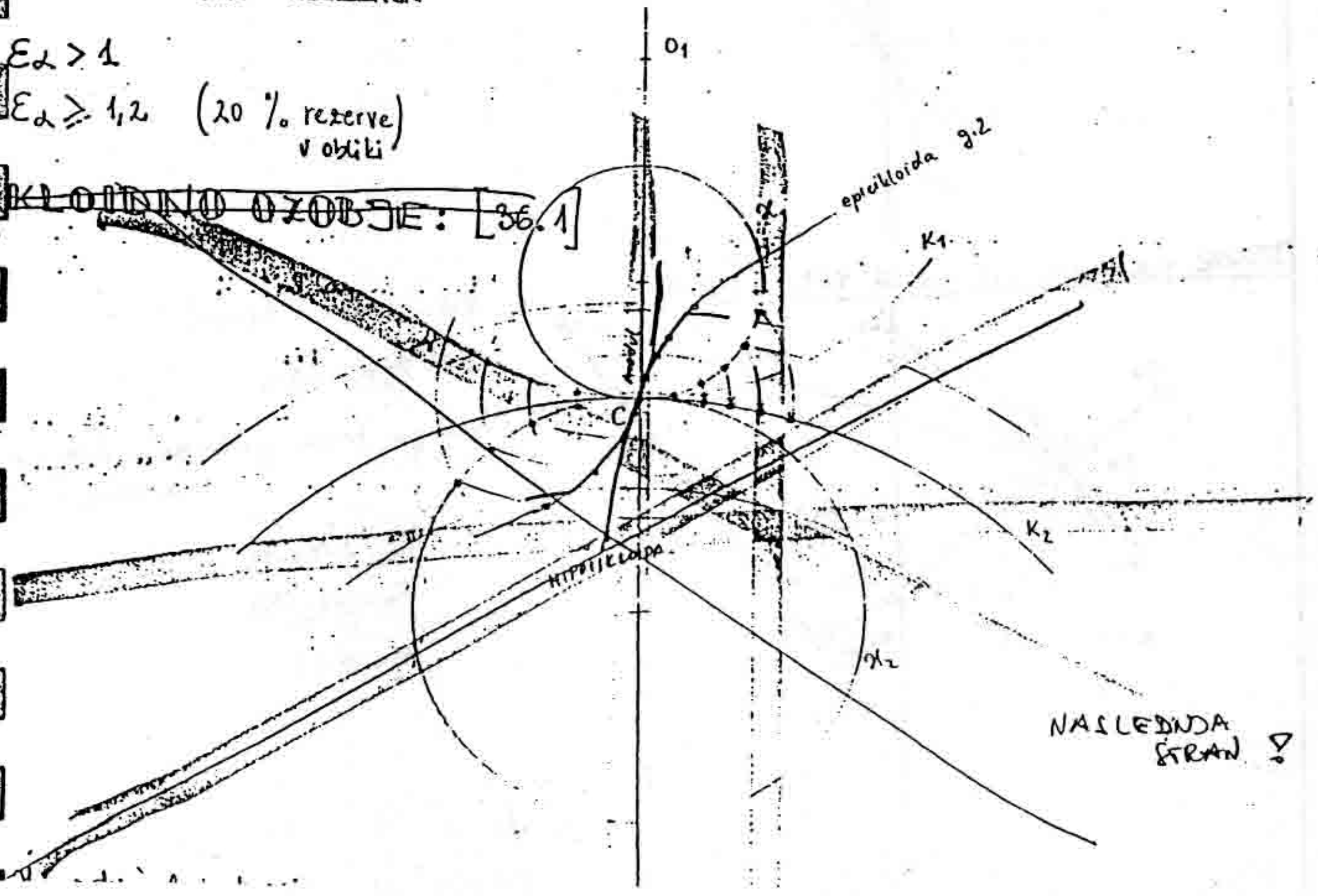
$$\varepsilon_\alpha = \frac{\text{ubirni lok}}{\text{delitev}} = \frac{\widehat{A_1CE_1}}{\widehat{t}}$$

ε_α.... STOPNJA PREKRITJA

$\varepsilon_\alpha > 1$

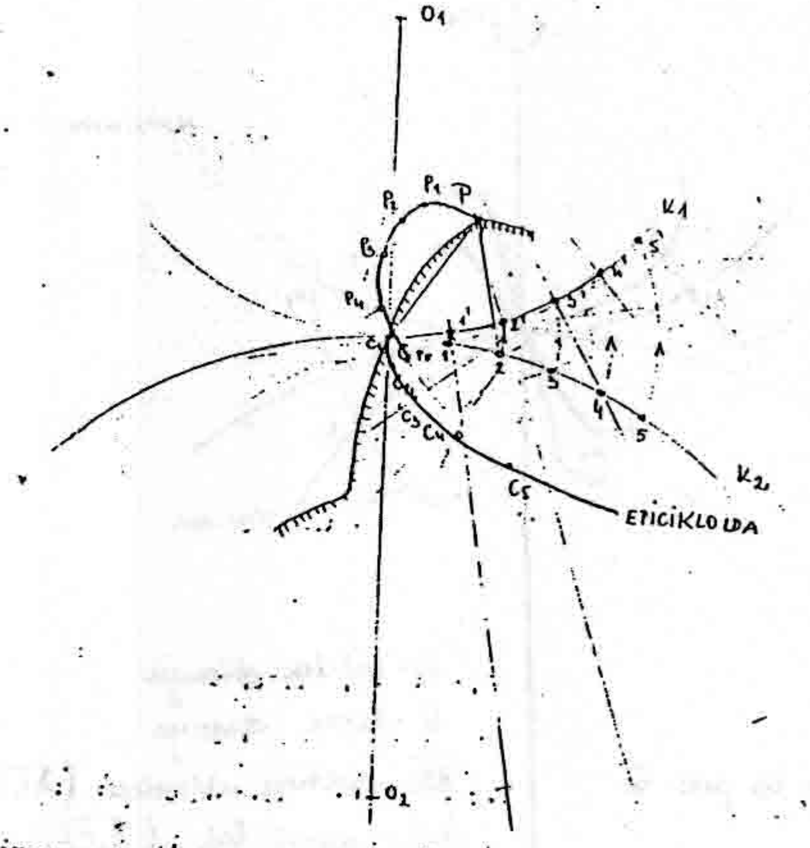
$\varepsilon_\alpha \geq 1{,}2$ (20 % rezerve v obliki)

KLOIDNO OZOBJE: [36.1]



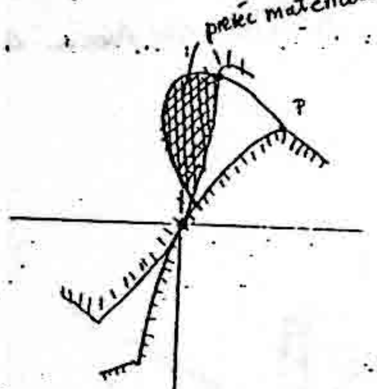
NASLEDNJA STRAN

obodne hitrosti enake
- fiksiram K1
- odkotalim K2 po K1

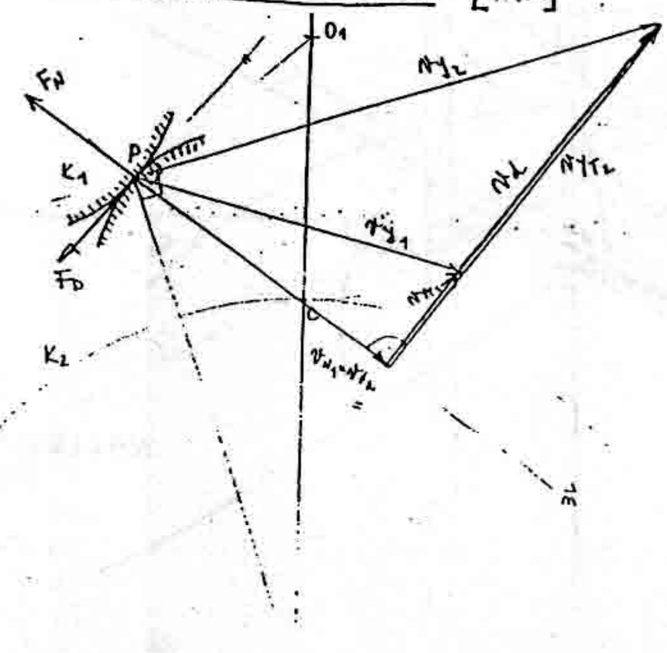


PRAKTIČNO:
- narišeš P
- izbereš točko 4 na
- preneseš v točko 4
- narediš tangento
- -||- normalo
- odkotališ $\overline{O_2C}$ skozi
- odkotališ $\overline{O_1 4}$ skozi
- dobiš presečišče C
- $\left.\begin{array}{l}\overline{4P}=\overline{4'P_4}\\ \overline{CP}=\overline{C_4P_4}\end{array}\right\} P_4$

v primeru:



DRSNE RAZMERE NA BOKIH ZOB: [29.1]



v_d.... drsna hitrost

$v_d = v_{yT_2} - v_{yT_1}$

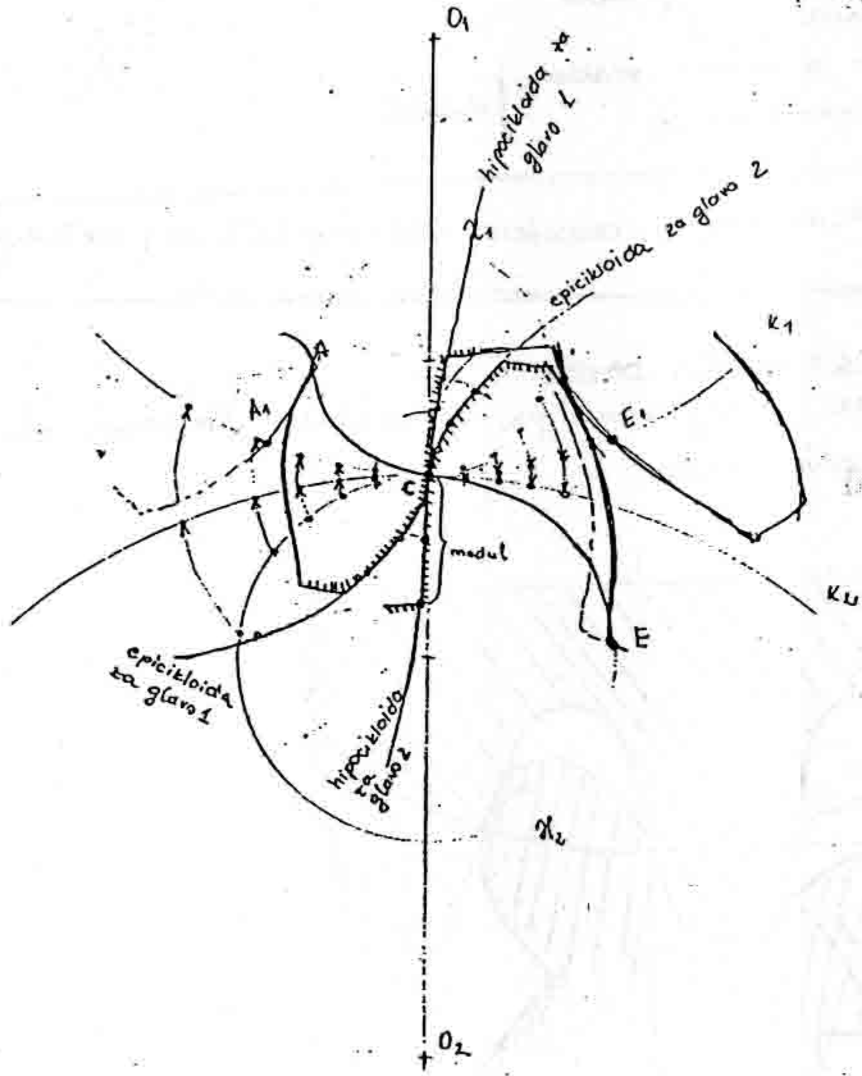
bok po boku podrsava (izgube, obraba,.....)

$P_{izg} = v_d \cdot F_D$

$F_D = \mu_g \cdot F_N$

$\eta = 0{,}99$

$\mathcal{K}_1, \mathcal{K}_2$; odvajalni kroga

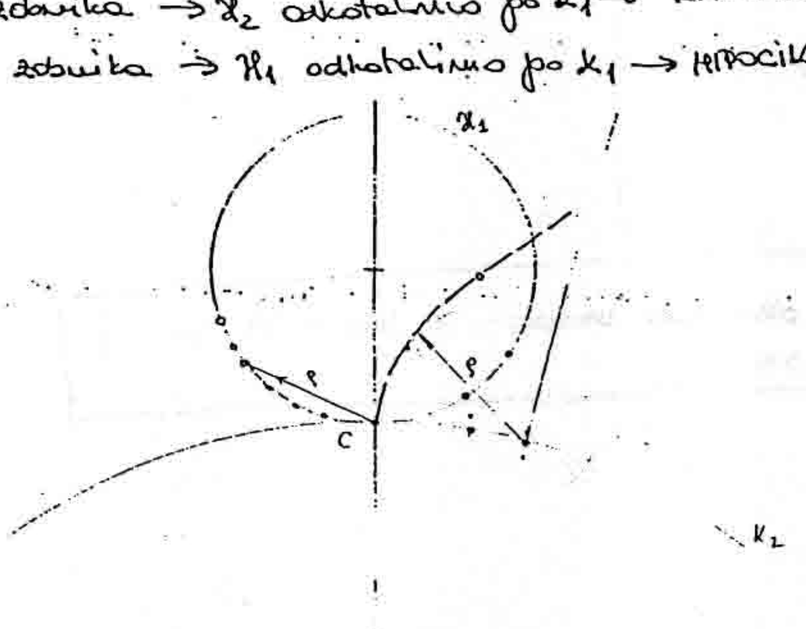


glava 2. zobnika → $\mathcal{K}_1$ odkotalimo po k_2 → EPICIKLOIDA

IZNOŽJE 2. zobnika → $\mathcal{K}_2$ odkotalimo po k_2 → HIPOCIKLOIDA

glava 1. zobnika → $\mathcal{K}_2$ odkotalimo po k_1 → EPICIKLOIDA

IZNOŽJE 2. zobnika → $\mathcal{K}_1$ odkotalimo po k_1 → HIPOCIKLOIDA



Dokaz, da so vse ubirne točke na valilnem krogu $\mathcal{K}_1$

- 6-8 zob na malem zobniku
- uporaba v finomehaniki } prednosti

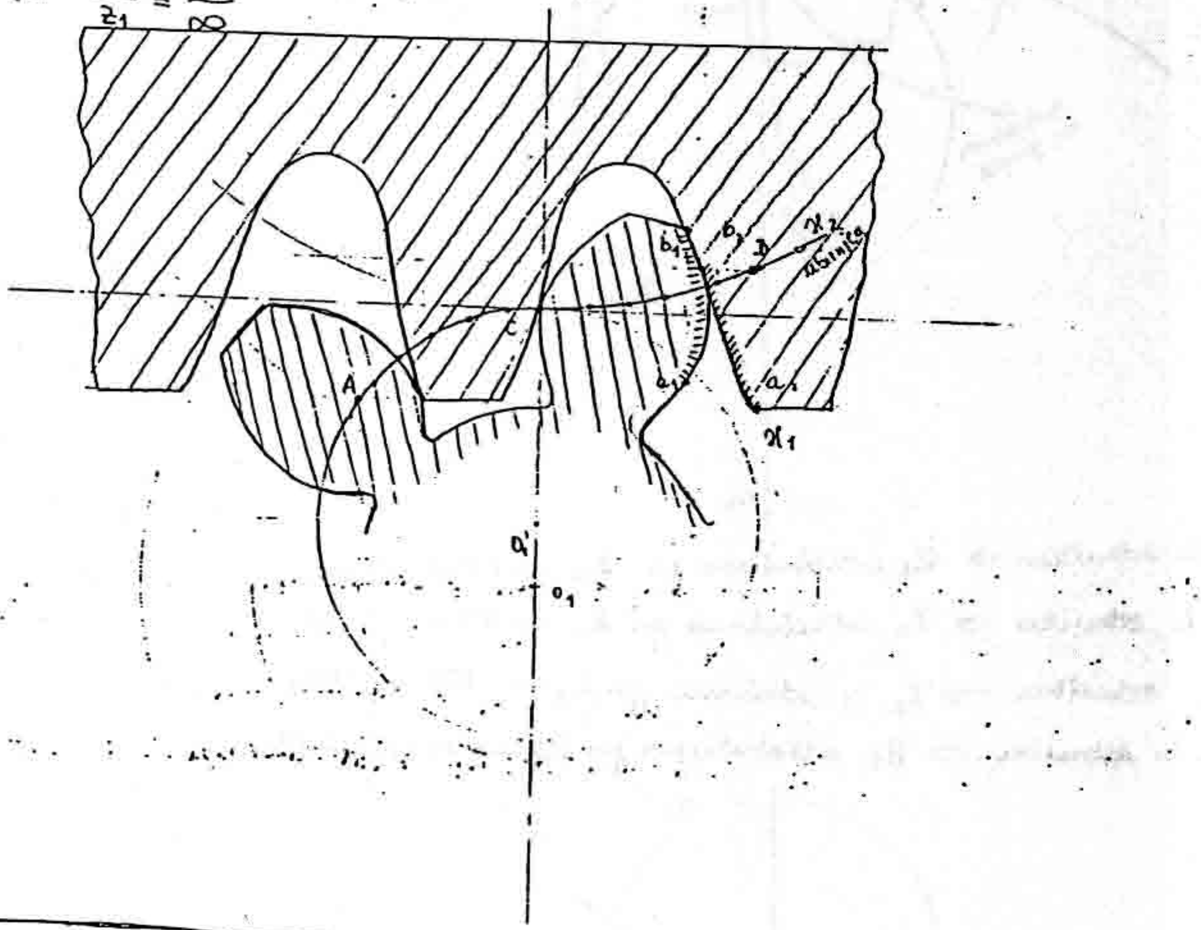
občutljivo na napake v medosni razdalji
za vsak valilni krog - novo orodje } slabosti

ZA KOLOKVIJ: SKICIRAJ CIKLOIDNO OZOBJE, OBIRNICO, OBRABNA DOLŽINO, DOLŽINO LOKA

PRIKAZ BISTVENE PREDNOSTI CIKLOIDNEGA OZOBJA:

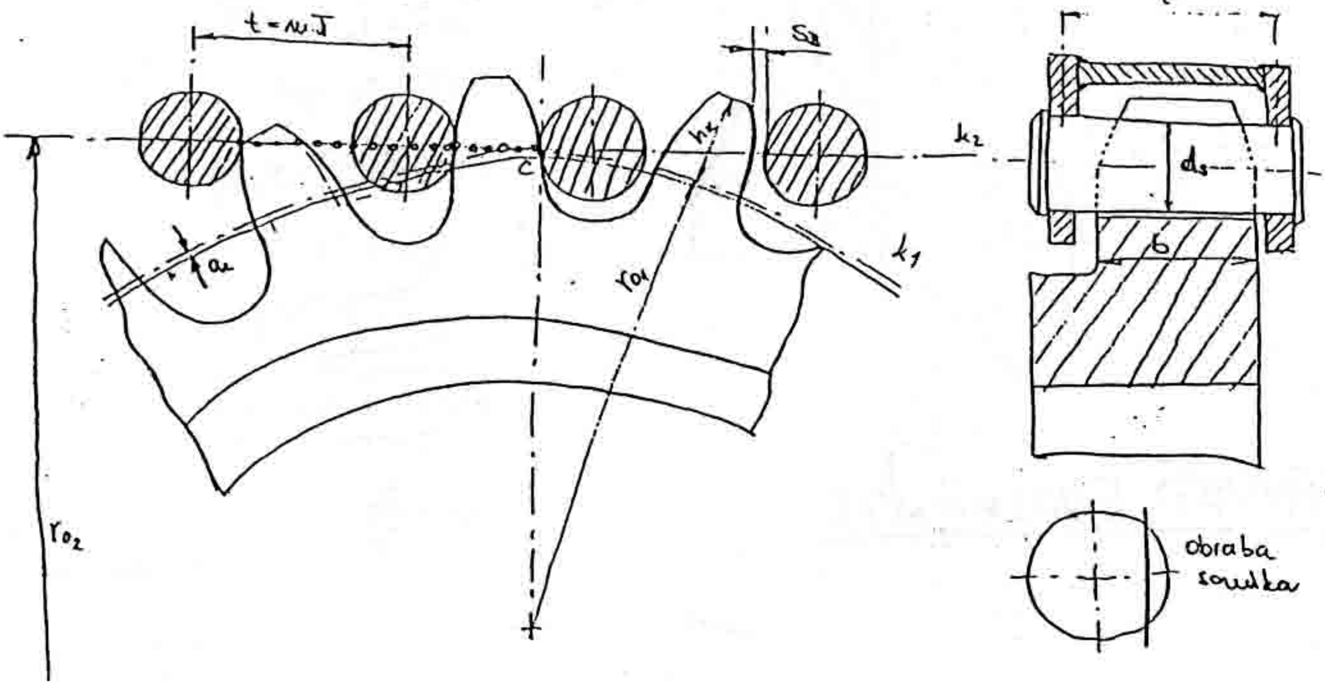
en zobnik v obliki letve, drug zobnik pa z malim številom zob.
posledica tega je zelo ugodna prestava

$$i = \frac{z_2}{z_1} = \frac{4}{\infty}$$

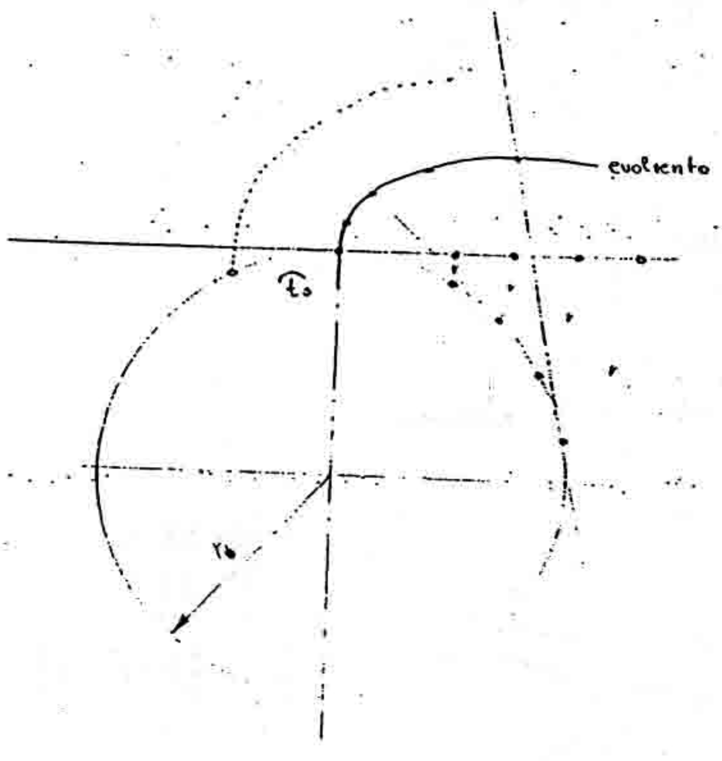


ZA KOLOKVIJ: SKICIRAJ CIKLOIDNO OZOBJE Z MALIM ŠT. ZOB Z ZOBATO LETVIJO.

- za velike prestave in majhne hitrosti
- sorniki so na enakih razdaljah. Delitev popišemo z modulom
- evolventa in cikloida sta enaki ko ima en krog neskončen polmer.
- ubirnica je ravna črta. Obrabna dolžina je cela glavica. Sornik pa ubira vedno v isti točki in se tam tudi obrabi.
- bok zoba ima obliko evolvente.



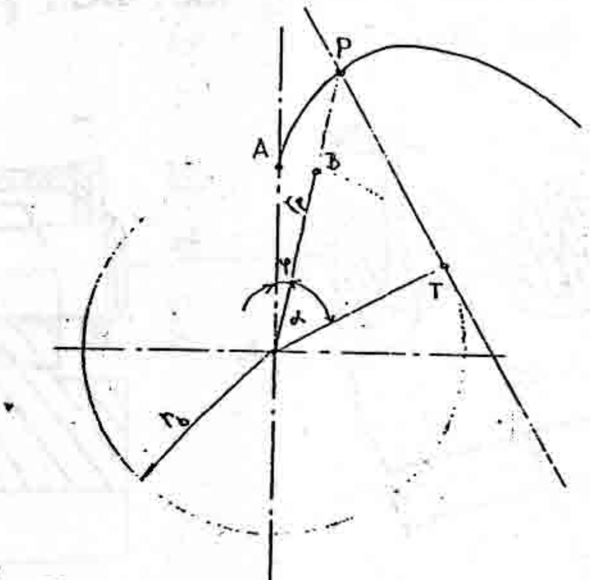
EVOLVENTNO OZOBJE



r_b .... osnovni krog

če je r_b znan je znana evolventa

α.... tvorni kot



$$\overline{PT} = \widehat{ABT}$$

$$\widehat{ABT} = r_b \cdot (\widehat{\alpha} + \widehat{\varphi})$$

$$\overline{PT} = r_b \cdot tg\,\alpha$$

$$\cancel{r_b} \cdot (\widehat{\alpha} + \widehat{\varphi}) = \cancel{r_b} \cdot tg\,\alpha$$

$$tg\,\alpha = \widehat{\alpha} + \widehat{\varphi}$$

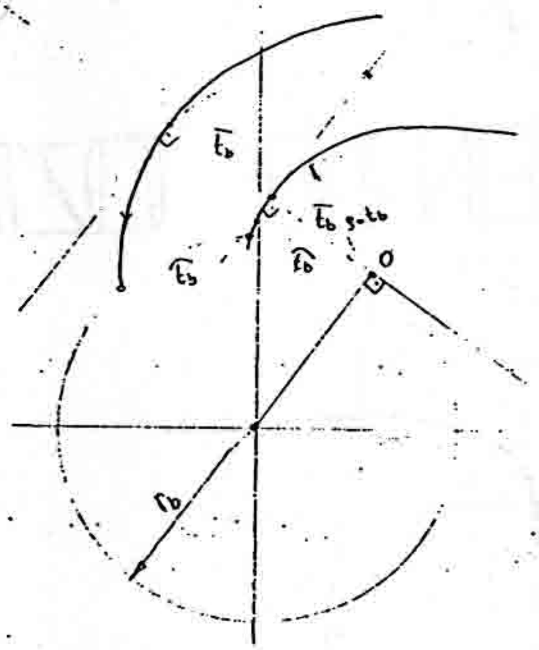
$$\boxed{tg\,\alpha - \widehat{\alpha} = \widehat{\varphi}}$$

$$\boxed{tg\,\alpha - \widehat{\alpha} = ev\,\alpha}$$

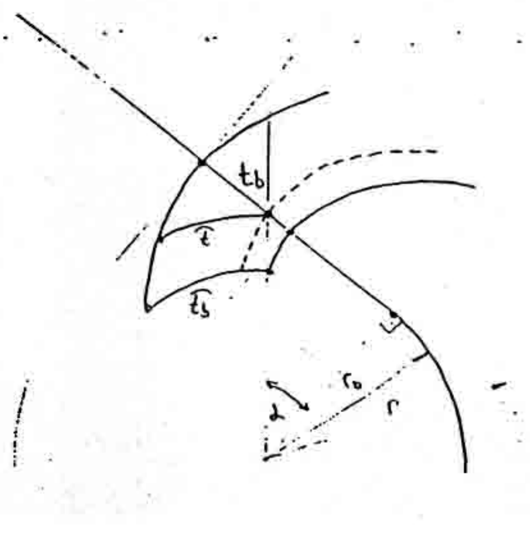
ASTNOSTI EVOLVENTE:

$$\cos\alpha = \frac{r_b}{r_p}$$

r... radij ukrivljenosti

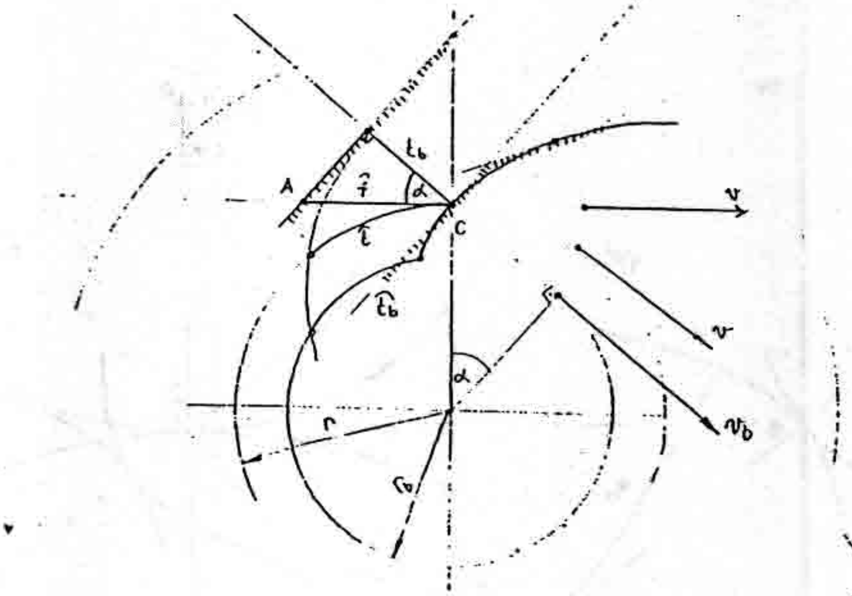


premica p je skupna normala vseh evolvent.

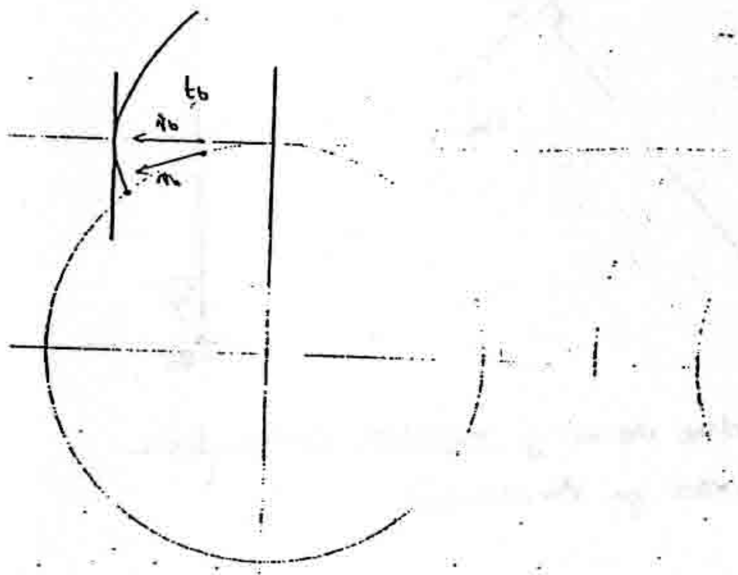


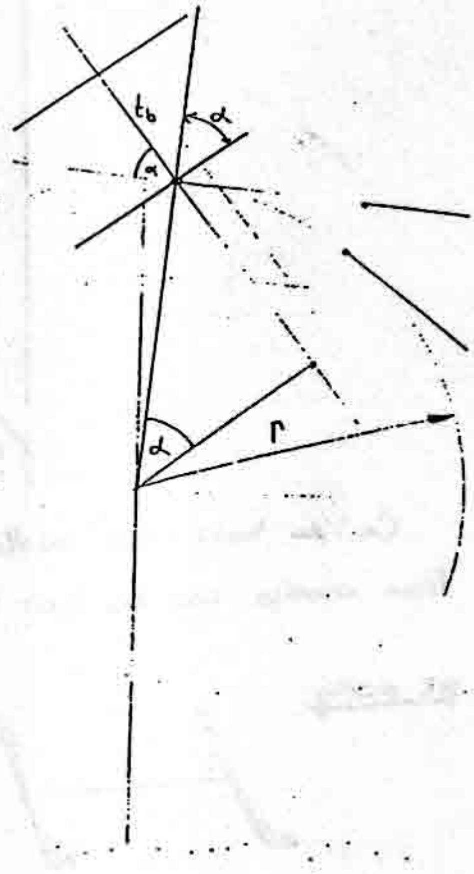
$$z \cdot \widehat{t_b} = 2\pi \cdot r_b$$
$$z \cdot \widehat{t} = 2\pi \cdot r$$

$$\frac{\widehat{t_b}}{\widehat{t}} = \frac{r_b}{r} = (\cos\alpha)$$

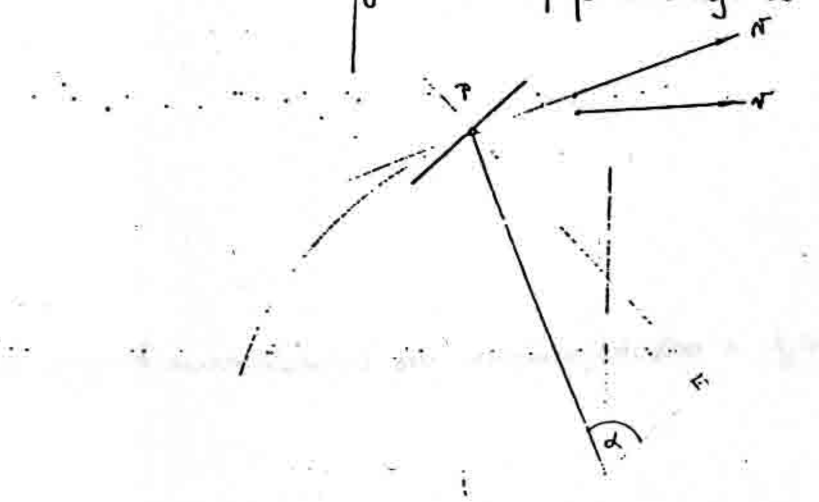


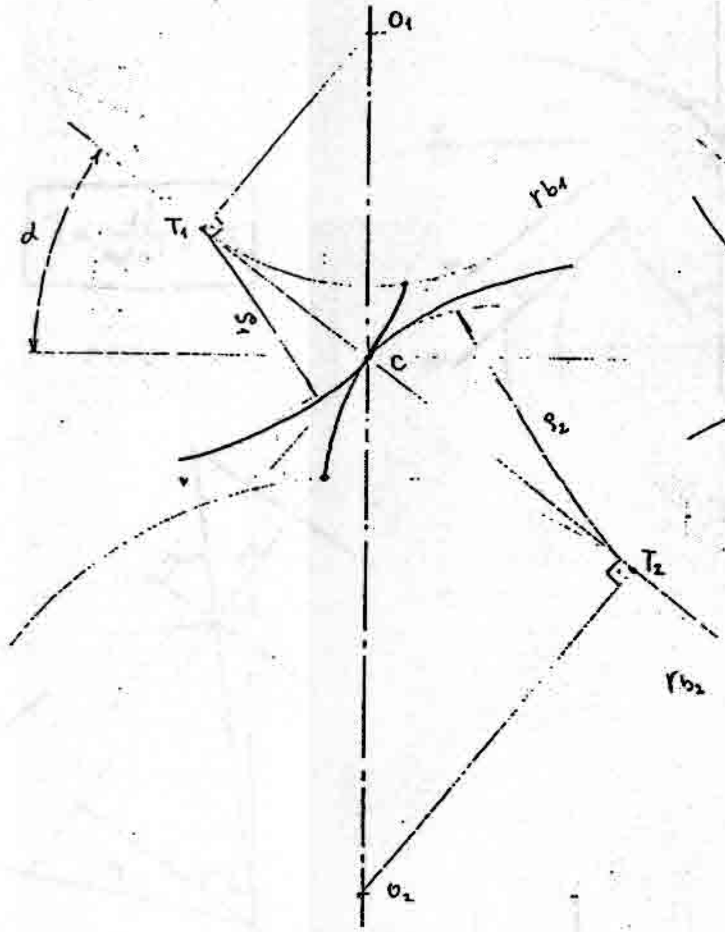
$$\boxed{\overline{AC} = \frac{t_b}{\cos\alpha} = \hat{t}}$$

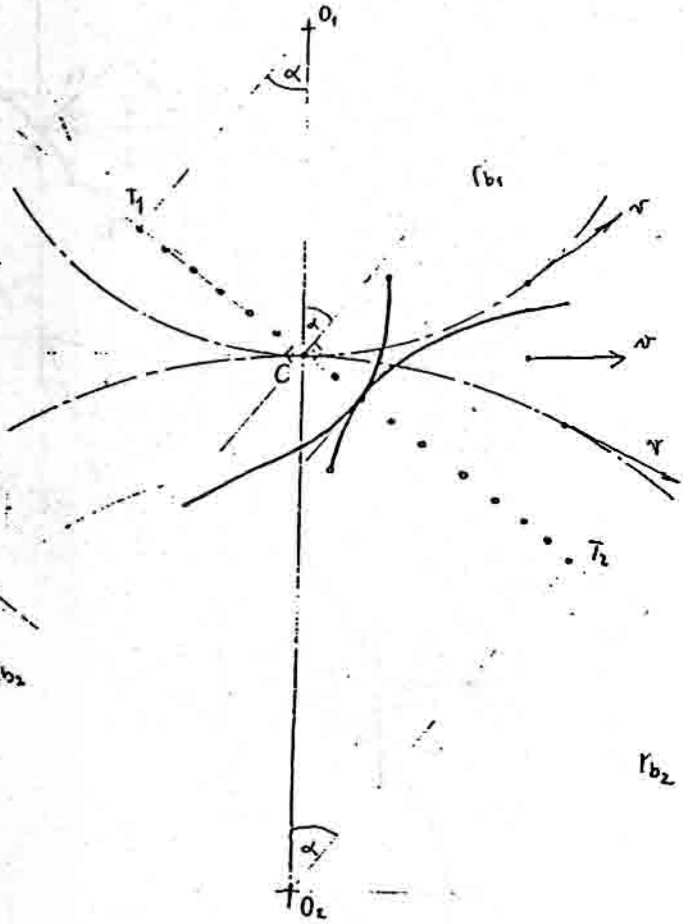




$\alpha = 0 \Rightarrow$ Osnovni krog se odkotaljuje od tangente

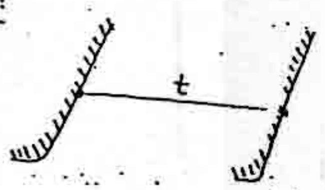






Če so boki zob evolventne oblike je <u>ubirnica ravna črta</u>.
Eno orodje za en kot ($\alpha = 20°$ po standardu)

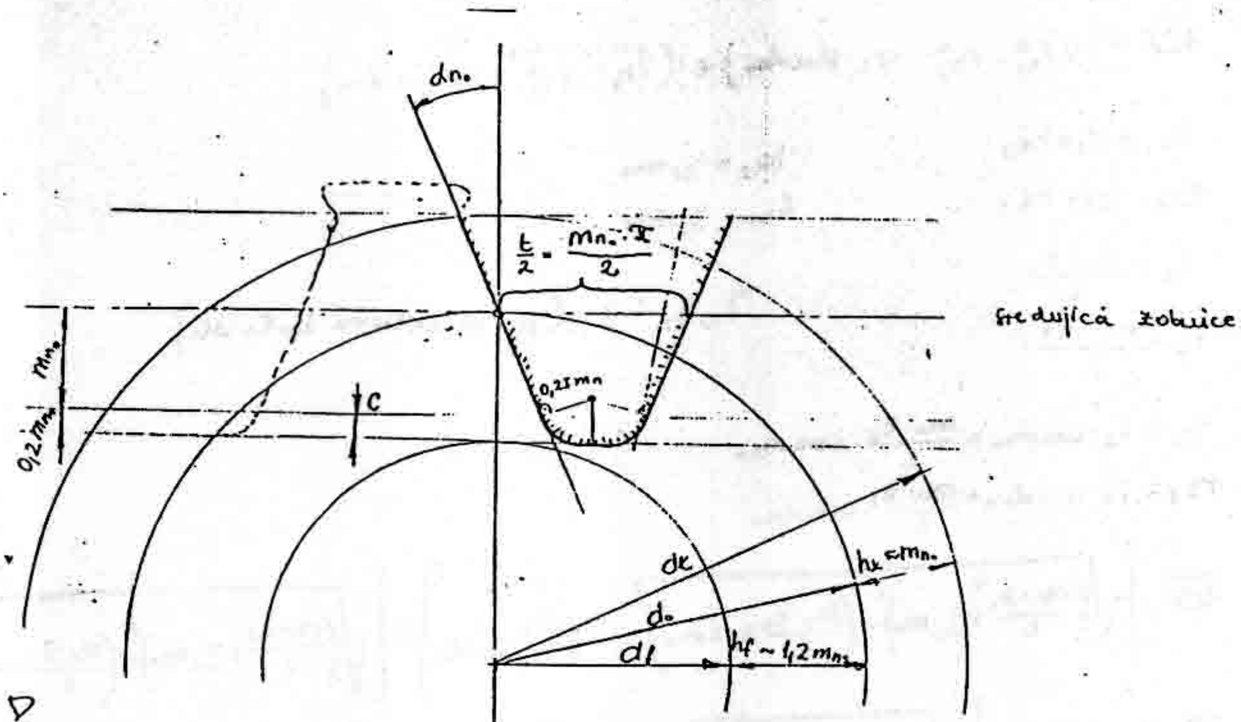
<u>več orodij:</u>



$\hat{t} = t = m \cdot \pi$

$\alpha_{n_0} = 20°$

Zagotovi evolventno ozobje z odkotaljevanjem na razdelbnem krogu d_0.

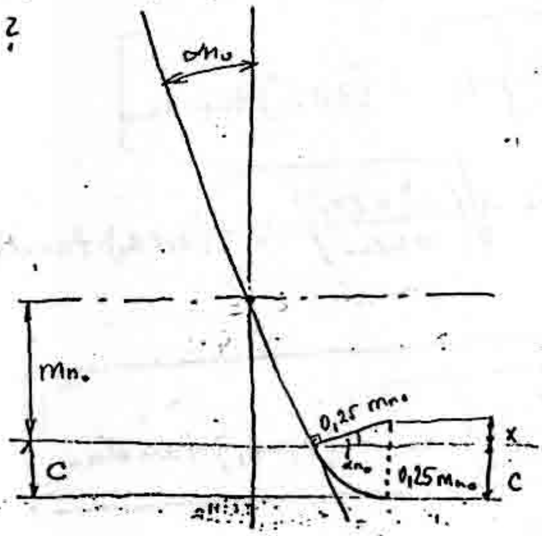


D. N. ?

Dokazati kolikšna je razalja „C".

$\alpha_n = 20°$

$C = ?$



$$x + c = 0{,}25\, m_{n_o}$$

$$\sin \alpha_{n_o} = \frac{x}{0{,}25\, m_{n_o}}$$

$$x = \sin\alpha_{n_o} \cdot 0{,}25 \cdot m_{n_o}$$

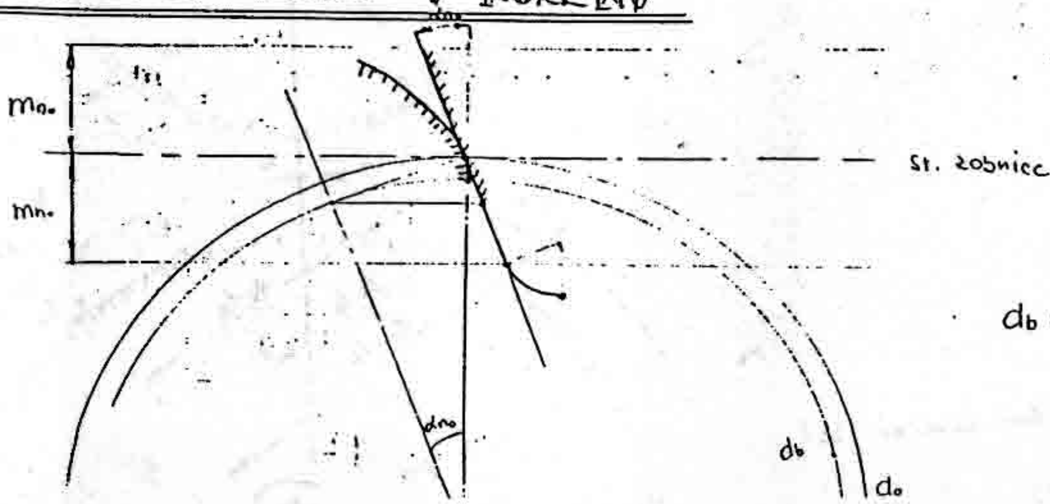
$$\sin\alpha_{n_o} \cdot 0{,}25 \cdot m_{n_o} + c = 0{,}25 \cdot m_{n_o}$$

$$\boxed{c = 0{,}25 \cdot m_{n_o} \left[1 - \sin \alpha_{n_o} \right]}$$

$$c = 0{,}25 \cdot m_{n_o} \left[1 - \sin 20 \right]$$

$$c = 0{,}1645\, m_{n_o} \approx 0{,}2 \cdot m_{n_o}$$

ZAOKROŽITEV ZOBA V KORENU



$$d_b = d_o \cdot \cos \alpha_{n_o}$$

1. del.

$$ACE = \left(\sqrt{r_{k_2}^2 - r_{b_2}^2} - r_2 \cdot \sin\alpha_{no}\right) + \left(\sqrt{r_{k_1}^2 - r_{b_1}^2} - r_1 \cdot \sin\alpha_{no}\right)$$

$r_{k_2} = r_2 + h_{k_2}$ $\qquad h_{k_2} = y_2 \cdot m_n$

$r_{k_1} = r_1 + h_{k_1}$ $\qquad h_{k_1} = y_1 \cdot m_n$

$r_2 = \frac{m_n \cdot z_2}{2}$

$r_1 = \frac{m_n \cdot z_1}{2}$ $\qquad y_1, y_2 \doteq 1$ (pri nizelnih kolesih)

$r_{b_2} = r_2 \cdot \cos\alpha_{no} = \frac{m_n \cdot z_2}{2} \cdot \cos\alpha_{no}$

$r_{b_1} = r_1 \cdot \cos\alpha_{no} = \frac{m_n \cdot z_1}{2} \cdot \cos\alpha_{no}$

$$\overline{ACE} = \left[\sqrt{\left(\frac{m_n \cdot z_2}{2} + y_2 \cdot m_n\right)^2 - \left(\frac{m_n \cdot z_2}{2} \cdot \cos\alpha_{no}\right)^2} - \frac{m_n \cdot z_2}{2} \cdot \sin\alpha_{no}\right] + \left[\sqrt{\left(\frac{m_n \cdot z_1}{2} + y_1 \cdot m_n\right)^2 - \left(\frac{m_n \cdot z_1}{2} \cdot \cos\alpha_{no}\right)^2} - \frac{m_n \cdot z_1}{2} \cdot \sin\alpha_{no}\right]$$

$$\overline{ACE} = \frac{m_n \cdot \cos\alpha_{no}}{2}\left[\sqrt{\left(\frac{z_2 + 2y_2}{\cos\alpha_{no}}\right)^2 - z_2^2} - z_2 \cdot \tan\alpha_{no}\right] + \frac{m_n \cos\alpha_{no}}{2}\left[\sqrt{\left(\frac{z_1 + 2y_1}{\cos\alpha_{no}}\right)^2 - z_1^2} - z_1 \cdot \tan\alpha_{no}\right]$$

$$\overline{ACE} = \frac{m_n \cdot \cos\alpha_{no}}{2}\left[\sqrt{\left(\frac{z_1 + 2y_1}{\cos\alpha_{no}}\right)^2 - z_1^2} + \sqrt{\left(\frac{z_2 + 2y_2}{\cos\alpha_{no}}\right)^2 - z_2^2} - (z_1 + z_2) \cdot \tan\alpha_{no}\right]$$

$$\varepsilon_\alpha = \frac{\overline{ACE}}{t_b} = \frac{\cancel{m_n \cdot \cos\alpha_{no}}}{2 \cdot \pi \cdot \cancel{m_n \cdot \cos\alpha_{no}}} \cdot \left[\sqrt{\left(\frac{z_1 + 2y_1}{\cos\alpha_{no}}\right)^2 - z_1^2} + \sqrt{\left(\frac{z_2 + 2y_2}{\cos\alpha_{no}}\right)^2 - z_2^2} - (z_1 + z_2) \cdot \tan\alpha_{no}\right]$$

upoštevam $y_1 = y_2 = 1$

$$\boxed{\varepsilon_\alpha = \frac{1}{2\pi} \cdot \left[\sqrt{\left(\frac{z_1 + 2}{\cos\alpha_{no}}\right)^2 - z_1^2} + \sqrt{\left(\frac{z_2 + 2}{\cos\alpha_{no}}\right)^2 - z_2^2} - (z_1 + z_2) \cdot \tan\alpha_{no}\right]}$$

Pogosto pa je čelna stopnja prekritja ε_α podana z izrazom:

$\varepsilon_\alpha = \varepsilon_1 + \varepsilon_2 - \varepsilon_a$

$\overline{T_1 E} = \varepsilon_1 \cdot t_b$

$\overline{T_2 A} = \varepsilon_2 \cdot t_b$

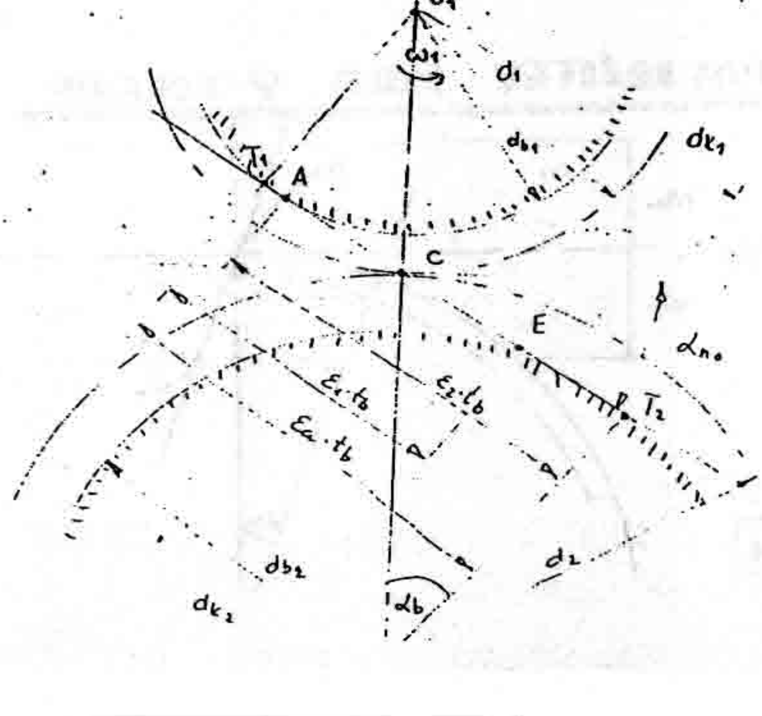
$\overline{T_1 T_2} = \varepsilon_a \cdot t_b$

$\varepsilon_1 = \frac{\sqrt{r_{k_1}^2 - r_{b_1}^2}}{t_b}$

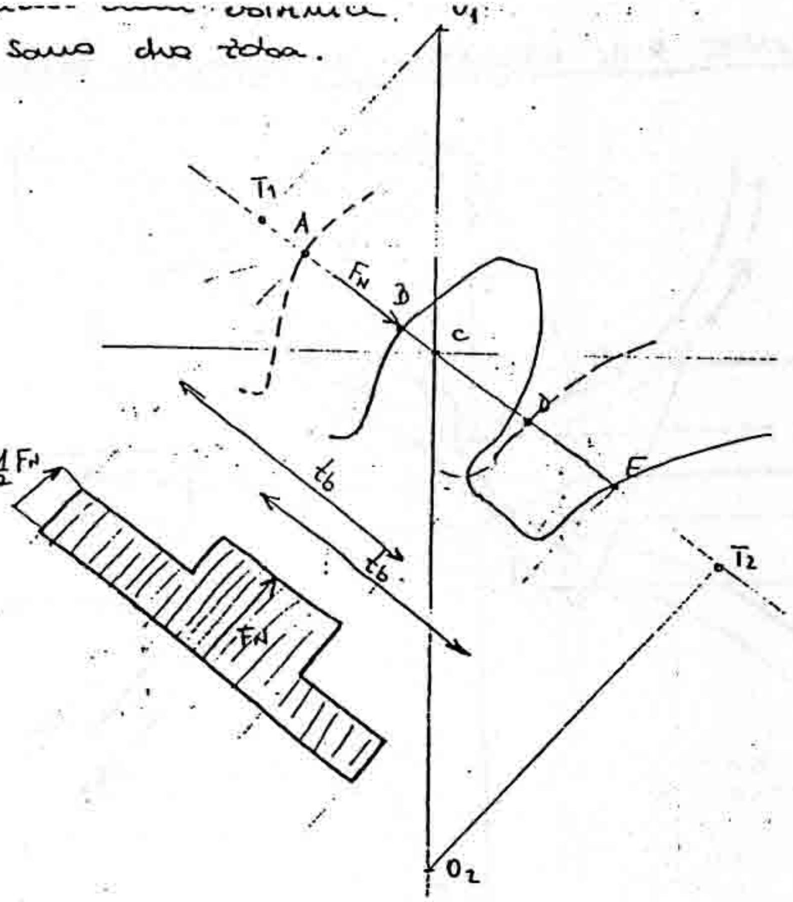
$\varepsilon_2 = \frac{\sqrt{r_{k_2}^2 - r_{b_2}^2}}{t_b}$

$\varepsilon_a = \frac{a \cdot \sin\alpha_b}{t_b}$

α_b.... obratovalni ubirni kot



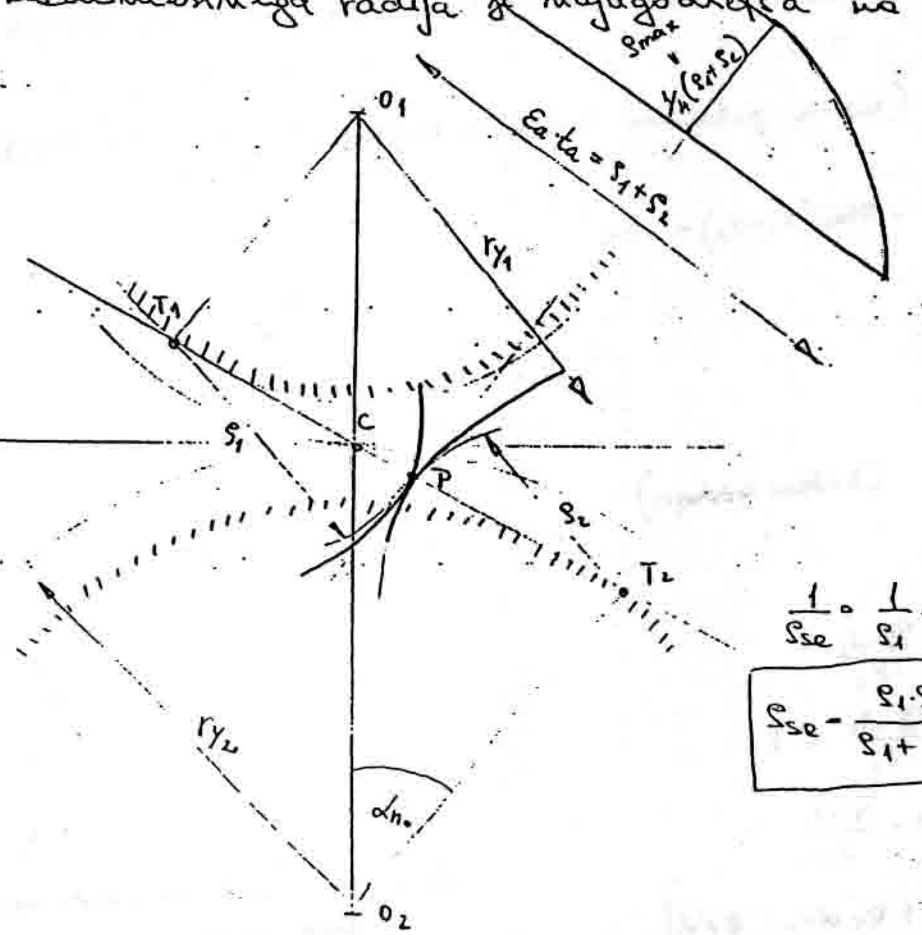
... obrnica.
ubirata samo dva zoba.



* KRIVINSKI RADIJ EVOLVENTE:

razdalja $\overline{T_1T_2} = \rho_1 + \rho_2 =$ stalna

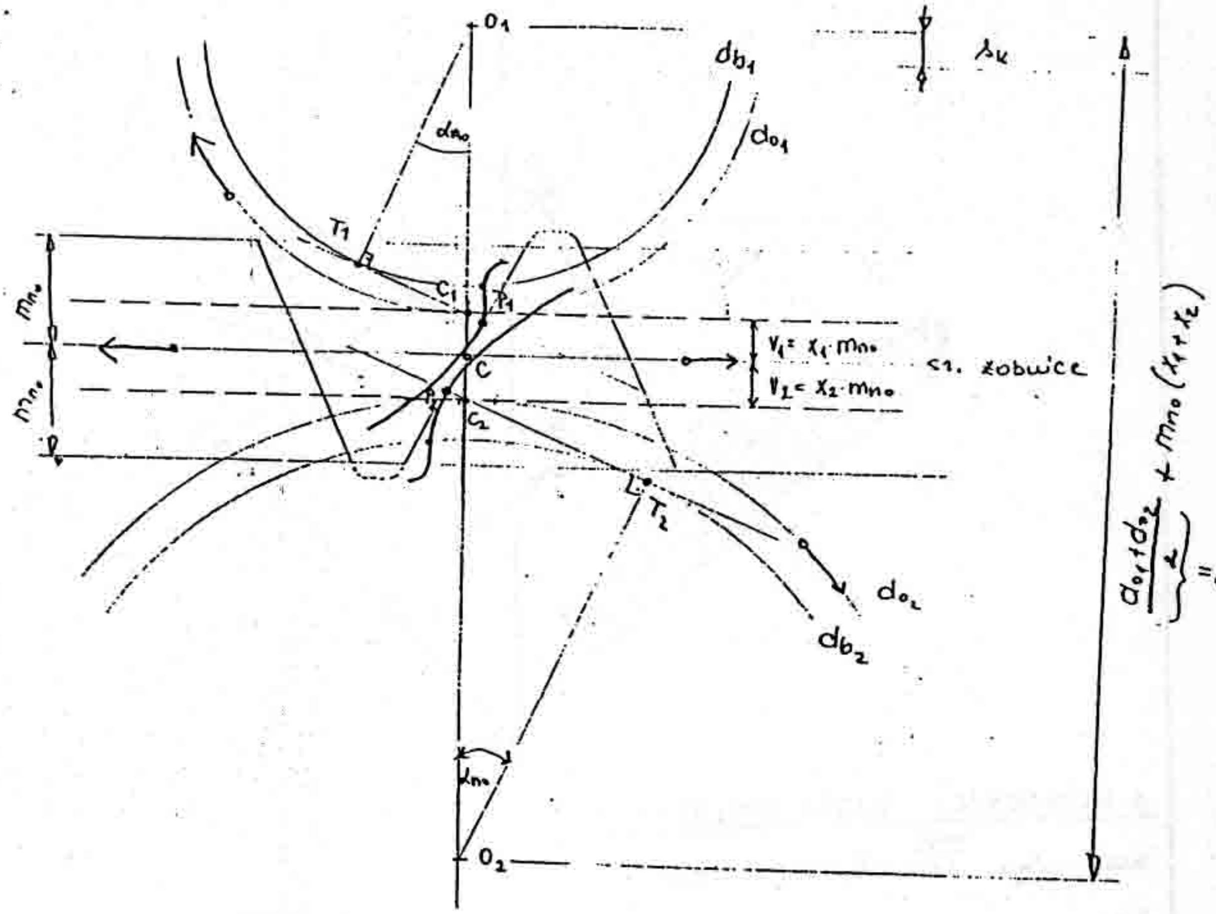
Sprememba nadomestnega radija je najugodnejša na sredini.



$$\frac{1}{\rho_{se}} = \frac{1}{\rho_1} + \frac{1}{\rho_2}$$

$$\boxed{\rho_{se} = \frac{\rho_1 \cdot \rho_2}{\rho_1 + \rho_2}}$$

OBLIKA IN UBIRANJE ZOB IZDELANE S PROFILNIM PREMIKOM:



. KOLIKO MORAMO ZOBNIKA PRIMAKNITI, DA MED NJIMA NI VRZELI:

$= ?$

$r_2 = ?$ (nova polmera kotalnih krogov, ki se bosta dotikala v kinematski točki

$= \frac{d_{o1}+d_{o2}}{2} + m_{no}(x_1+x_2) - s_k$

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

$= \frac{d_2}{d_1}$

$/d_2 \to C$ (zakon ozobja)

$_1 = \widehat{e_2}$

$= \widehat{e_1}$

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

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

$-\widehat{s_2} = \frac{\pi \cdot d_1}{z_1} = \frac{\pi \cdot d_2}{z_2}$

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

α .... novi kot, ki nastane pri primiku zobnikov

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

$$\widehat{s_{01}} = \frac{m_{no}\cdot\pi}{2} + 2\cdot m_{no}\cdot x_1\cdot tg\alpha_{no}$$

$$\widehat{s_{02}} = \frac{m_{no}\cdot\pi}{2} + 2\cdot m_{no}\cdot x_2\cdot tg\alpha_{no}$$

$$d_2 = i\cdot d_1$$

$$z_2 = i\cdot z_1$$

$$d_{01} = m_{no}\cdot z_1$$

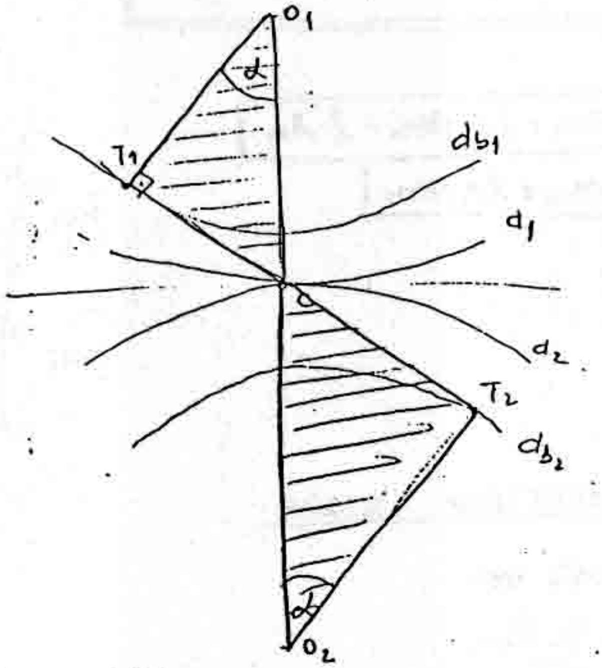
$$d_{02} = m_{no}\cdot z_2$$

$$d_{b1} = d_{01}\cdot\cos\alpha_{no}$$

$$d_{b2} = d_{02}\cdot\cos\alpha_{no}$$

$$d_1 = \frac{d_{b1}}{\cos\alpha} = \frac{d_{01}\cdot\cos\alpha_{no}}{\cos\alpha}$$

$$d_2 = \frac{d_{b2}}{\cos\alpha} = \frac{d_{02}\cdot\cos\alpha_{no}}{\cos\alpha}$$



$$\widehat{s_1} + \widehat{s_2} = d_1\left[\frac{\widehat{s_{01}}}{d_{01}} + ev\alpha_{no} - ev\alpha\right] + d_2\left[\frac{\widehat{s_{02}}}{d_{02}} + ev\alpha_{no} - ev\alpha\right]$$

$$\frac{\pi\cdot d_1}{z_1} = d_1\cdot\frac{\widehat{s_{01}}}{d_{01}} + d_2\cdot\frac{\widehat{s_{02}}}{d_{02}} + ev\alpha_{no}\left[d_1 + d_2\right] - ev\alpha\left[d_1 + d_2\right] \quad \Big/ : (d_1 + d_2)$$

$$ev\alpha = \frac{d_1\cdot\frac{\widehat{s_{01}}}{d_{01}}}{(d_1+d_2)} + \frac{d_2\cdot\frac{\widehat{s_{02}}}{d_{02}}}{(d_1+d_2)} + ev\alpha_{no} - \frac{\pi\cdot d_1}{z_1\cdot(d_1+d_2)}$$

$$ev\alpha = \frac{\cancel{d_1}\cdot\frac{\widehat{s_{01}}}{d_{01}}}{\cancel{d_1}(1+\frac{d_2}{d_1})} + \frac{d_2\cdot\frac{\widehat{s_{02}}}{d_{02}}}{d_1(1+\frac{d_2}{d_1})} + ev\alpha_{no} - \frac{\pi}{z_1}\cdot\frac{\cancel{d_1}}{\cancel{d_1}(1+\frac{d_2}{d_1})}$$

$$ev\alpha = \frac{\frac{\widehat{s_{01}}}{d_{01}}}{(1+i)} + \frac{i\cdot\frac{\widehat{s_{02}}}{d_{02}}}{(1+i)} + ev\alpha_{no} - \frac{\pi}{z_1(1+i)}$$

$$ev\alpha = \frac{\frac{\cancel{m_{no}}\cdot\pi}{2} + 2\cdot\cancel{m_{no}}\,x_1\,tg\,\alpha_{no}}{\cancel{m_{no}}\cdot z_1\,(1+\frac{z_2}{z_1})} + \frac{\cancel{z_2}\cdot(\cancel{m_{no}}\cdot\pi/2 + 2\,\cancel{m_{no}}\,x_2\,tg\alpha_{no})}{z_1\,(1+\frac{z_2}{z_1})\cdot\cancel{m_{no}}\cdot\cancel{z_2}} + ev\alpha_{no} - \frac{\pi}{z_1(1+\frac{z_2}{z_1})}$$

$$ev\alpha = \frac{\frac{\pi}{2} + 2\cdot x_1\,tg\,\alpha_{no}}{(z_1+z_2)} + \frac{\frac{\pi}{2} + 2\,x_2\cdot tg\,\alpha_{no}}{(z_1+z_2)} + ev\,\alpha_{no} - \frac{\pi}{(z_1+z_2)}$$

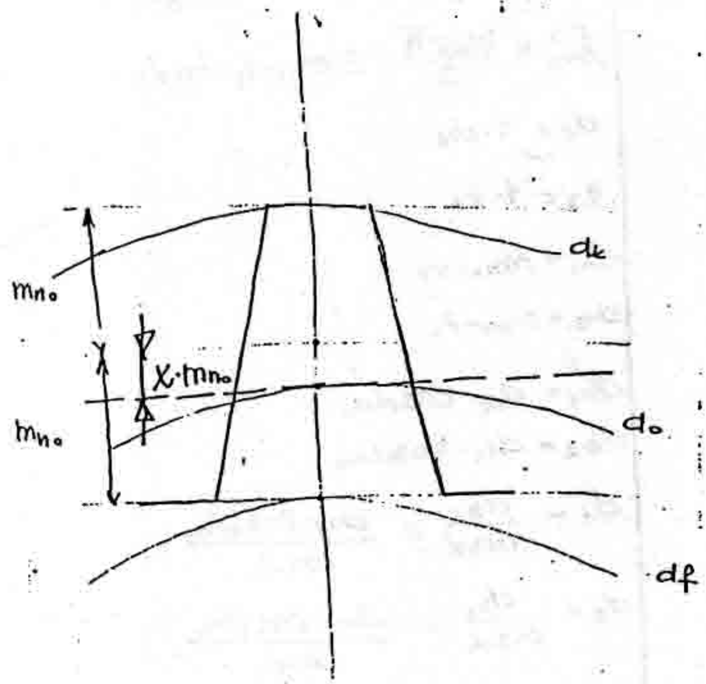
$$ev\alpha = \cancel{\frac{\pi}{(z_1+z_2)}} + 2\cdot\frac{(x_1+x_2)}{(z_1+z_2)}\cdot tg\alpha_{no} + ev\,\alpha_{no} - \cancel{\frac{\pi}{(z_1+z_2)}}$$

$$\boxed{ev\alpha = 2\cdot\frac{(x_1+x_2)}{(z_1+z_2)}\cdot tg\,\alpha_{no} + ev\,\alpha_{no}}$$

$$s_k = \frac{d_{o1}+d_{o2}}{2} + m_{no}(x_1+x_2) - \frac{d_1+d_2}{2}$$

$$\boxed{{}_k = d_o + 2\cdot m_{no} + 2x\cdot m_{no} - 2\cdot s_k}$$

$$\boxed{{}_f = d_o - 2{,}4\cdot m_{no} + 2x\cdot m_{no}}$$



ROKI ZA KOREKTURO OZOBJA:

inimalno število zob

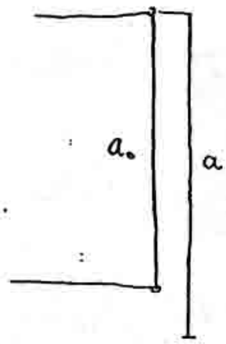
$$x_{min} = \frac{z-14}{17}$$

e želimo, da dva zobnika tečeta na okrogli medosni razdalji

$$a_o = \frac{m_{no}}{2}(z_1+z_2)$$

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

$$i = \frac{d_2}{d_1}$$



$_1, d_2 \rightarrow \alpha\,(d_b, d_o)$

$+x_2) = (ev\alpha - ev\alpha_o)\cdot\frac{z_1+z_2}{2}\cdot\frac{1}{tg\alpha_o}$

ko premika za vsak zob

$_1 > (x_1+x_2)$

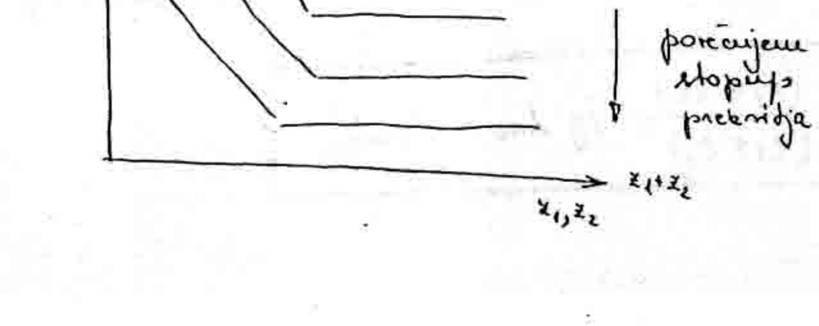
x_2

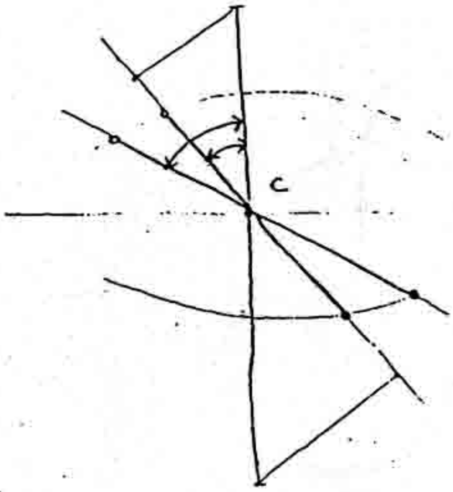
$_1 > x_{1min}$

$_1 + x_2 = 0{,}64352$

$_1 = 0{,}5000$

$_2 = 0{,}1452$

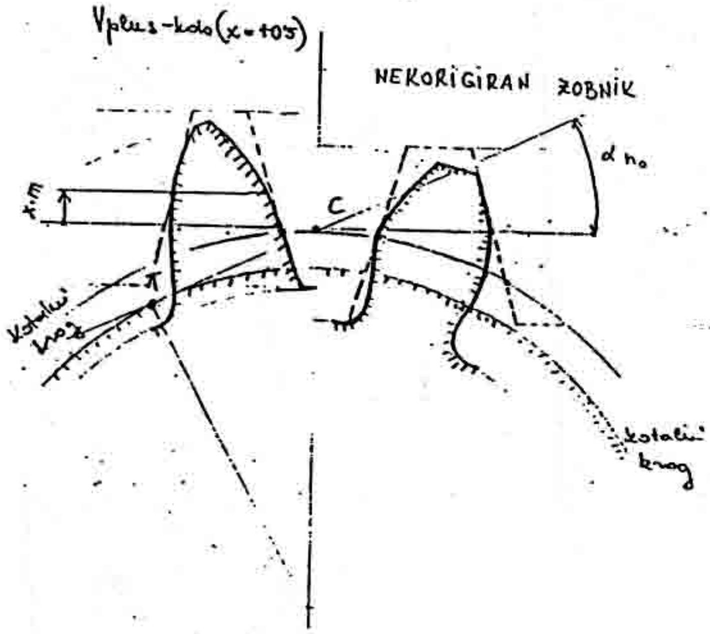


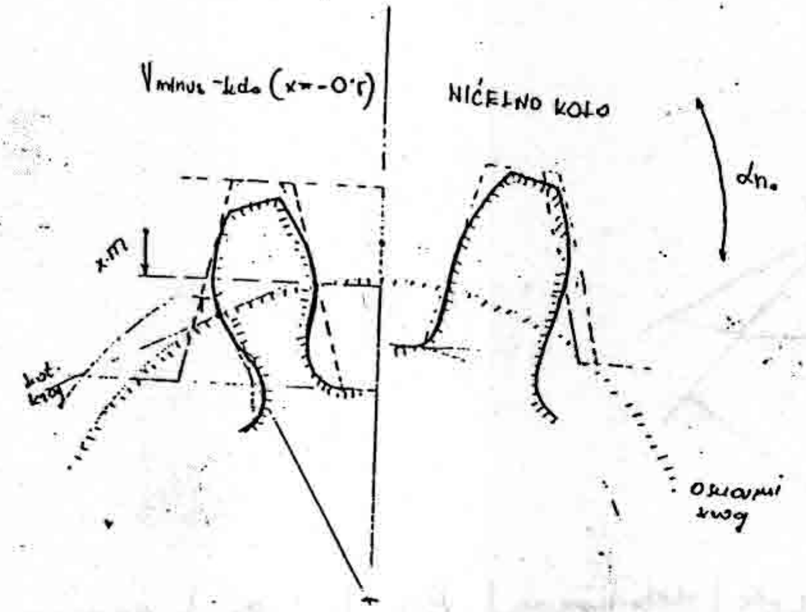


	x_1, x_2	deb. korena	ε_α	a	namen
enojna + korektura	$+x_1$	+	−	+	z_{min}
enojna − korektura	$-x_1; x_2$	−	+	−	ε_α
dvojna + korektura	$+x_1, +x_2$	++	−	+	$z_{min\,1,2}$
dvojna ± VO ⊣⊢	$+x_1=-x_2$	+ −	∅	∅	z_{min}, ε
enojna + 0,5 ⊣⊢	$x_1=0{,}5$	++	−	+	trdnost
dvojna ± ⊣⊢	$+x_1, -x_2$	+ −	2		a

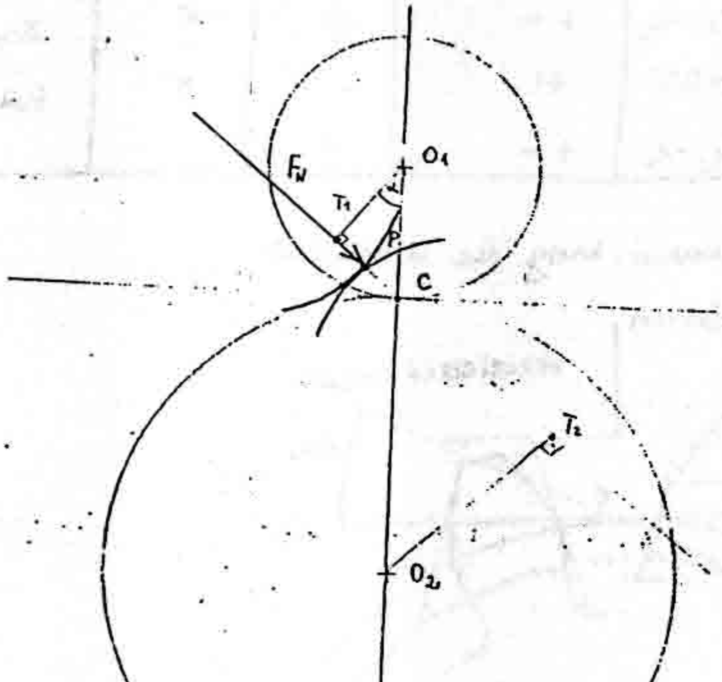
Pri korekturah se osnovni krog ne spremeni

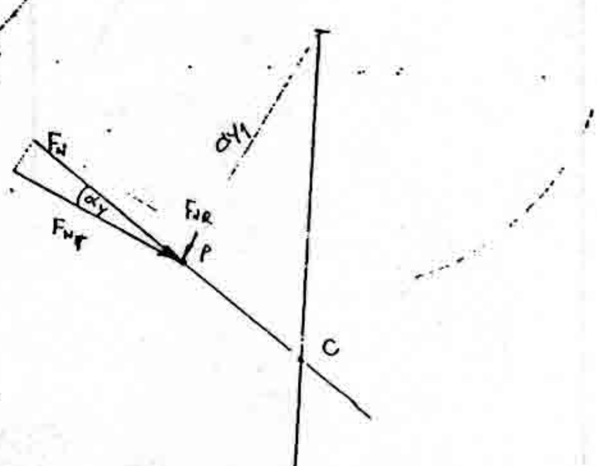
a)





SILE NA ČELNI ZOBNIK Z RAVNIMI ZOBMI:

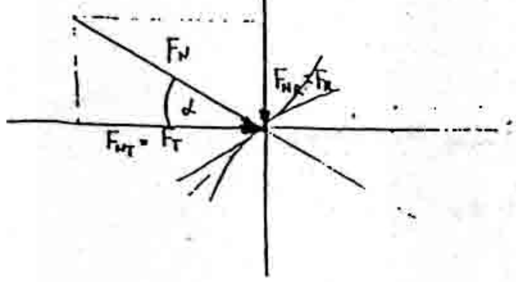




F_{NR}.... razpiralna sila

α_y.... trenuten ubirni kot

$M_{t1} = F_{NT} \cdot d_{y1}$



$$F_t = \frac{2M_{t1}}{d_1} = \frac{2M_{t2}}{d_2} \quad \text{pri } \eta = 1$$

$$F_R = F_t \cdot tg\alpha$$

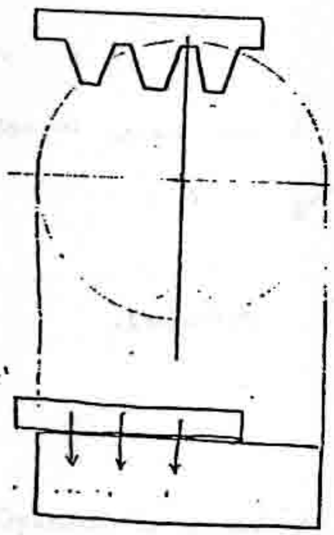
$$M_{t1} \longrightarrow F_t \longrightarrow F_r \longrightarrow F_N$$

$$F_N = \sqrt{F_t^2 + F_r^2}$$

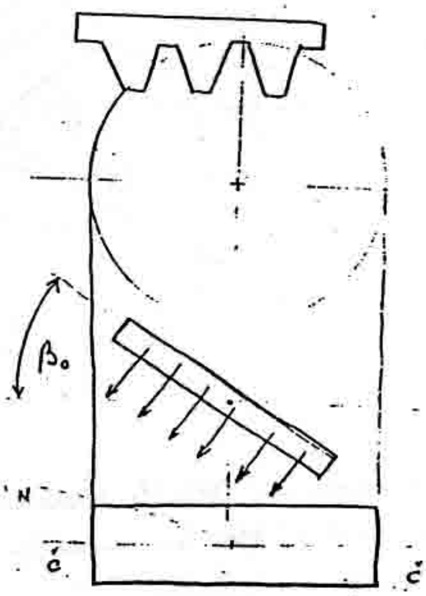
... je vektor, ki ga lahko premikam, F_N se ne spreminja, spreminjata pa njeni komponenti.

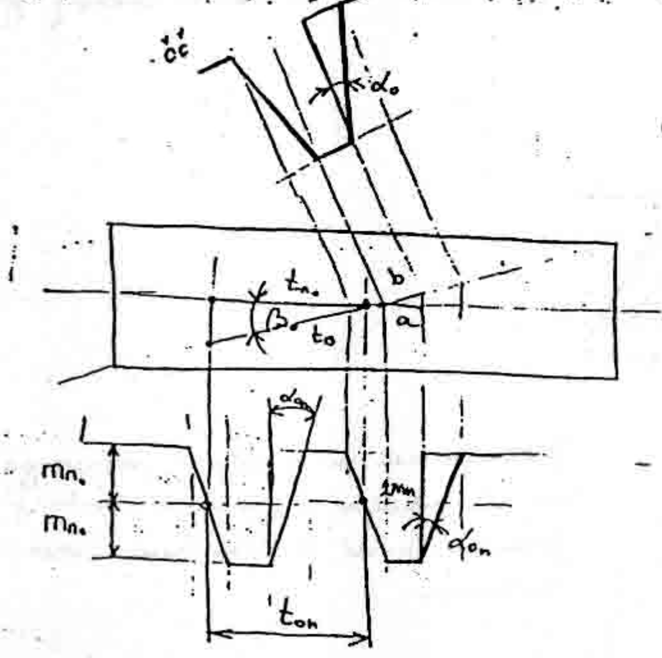
ČELNI ZOBNIKI S POŠEVNIMI ZOBMI

a) ravni zobje

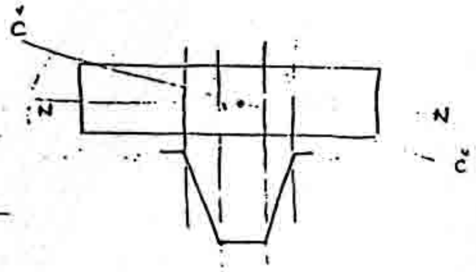


b) poševni zob





ŽOBNICA



$\beta_0 = \frac{a}{b}$

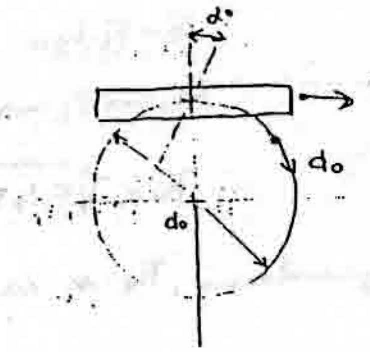
$tg\,\alpha_0 = \frac{b}{2m_{n0}} = \frac{a}{2m_{n0}\cos\beta_0}$ — $tg\,\alpha_{on}$

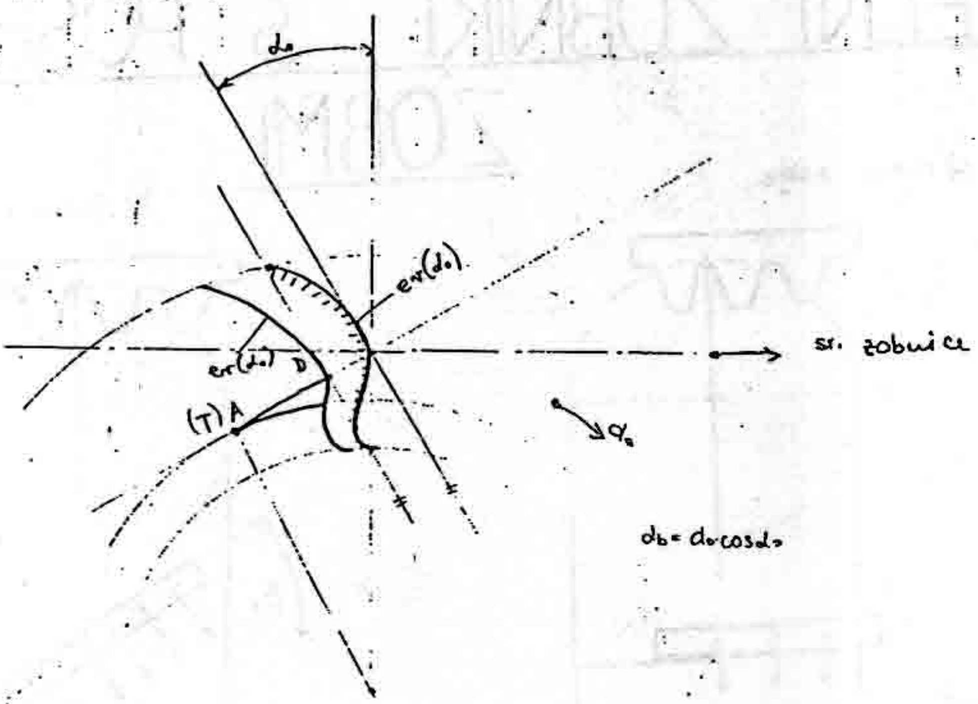
$$\boxed{\alpha_0 = \frac{tg\,\alpha_{on}}{\cos\beta_0}}$$

$t_{on} = m_{n0}\cdot\pi$

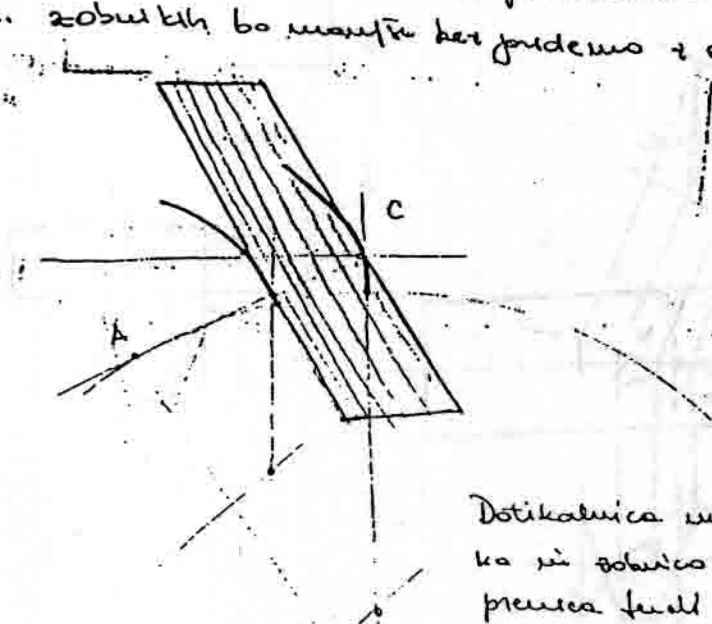
$$\boxed{t_0 = \frac{t_{on}}{\cos\beta_0}}$$

$$\boxed{m = \frac{m_{n0}}{\cos\beta_0}}$$



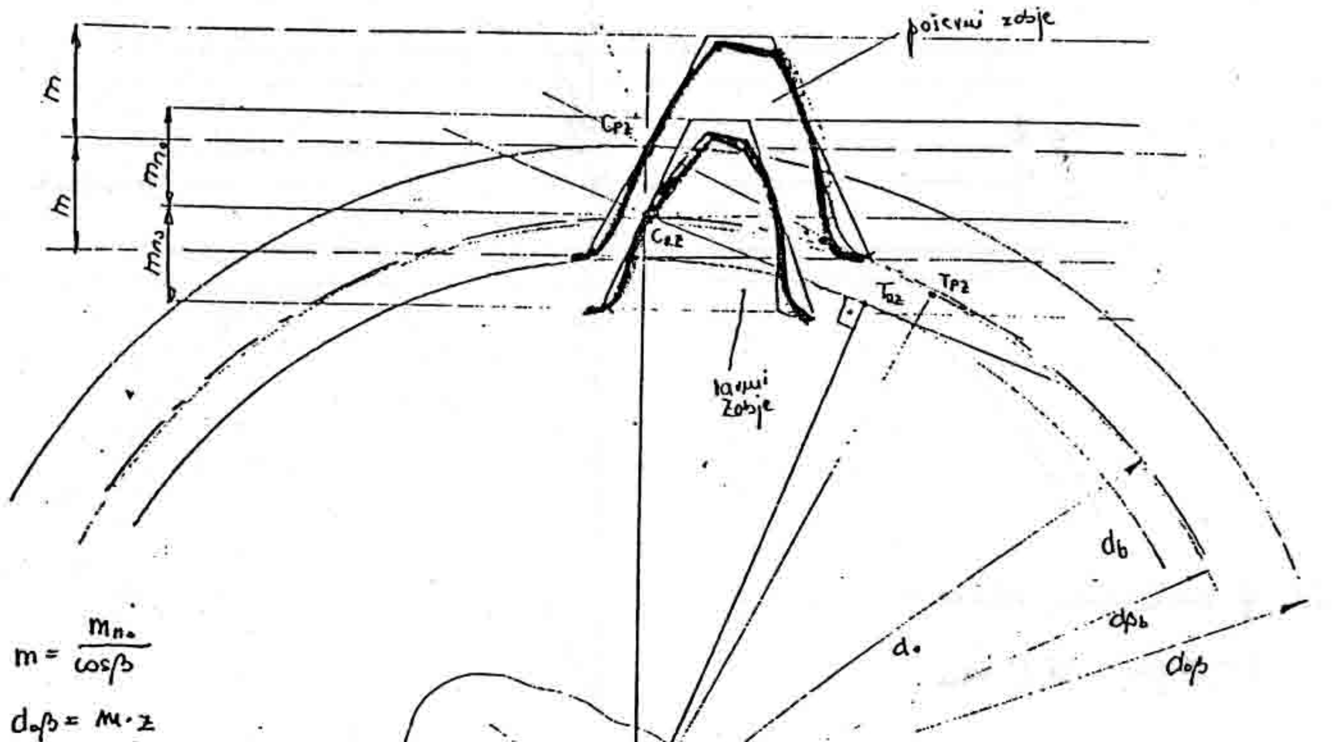


Snovni krog pri izdelavi čelnih zobnikov s poševnim ozobjem je manjši. Mejno število pri poš. zobnikih bo manjše ker pridemo z evolvento dovolj globoko



Dotikalnica med bokom poševnega zobnika in zobnico je premica, zato je premica tudi dotikalnica med obema bokoma.

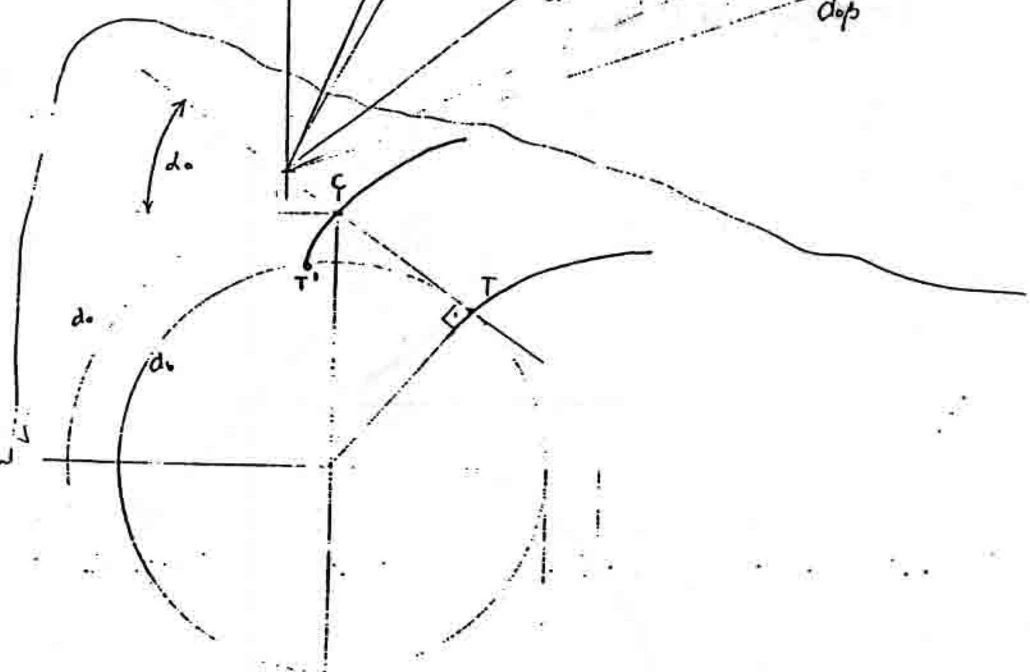
NARIŠI PRIMERJAVO MED CELNIM ZOBNIKOM Z RAVNIMI ZOBMI IN CELNIM ZOBNIKOM Z POŠEVNIM ZOBMI



$$m = \frac{m_{n0}}{\cos\beta}$$

$$d_{0\beta} = m \cdot z$$

$$\left.\begin{aligned} d_0 \cdot \cos\alpha_{0n} &= d_b \\ d_{0\beta} \cdot \cos\alpha_0 &= d_{b\beta} \end{aligned}\right\} :$$



$$\frac{d_b}{d_{b\beta}} = \frac{d_0}{d_{0\beta}} \cdot \frac{\cos\alpha_{0n}}{\cos\alpha_0}$$

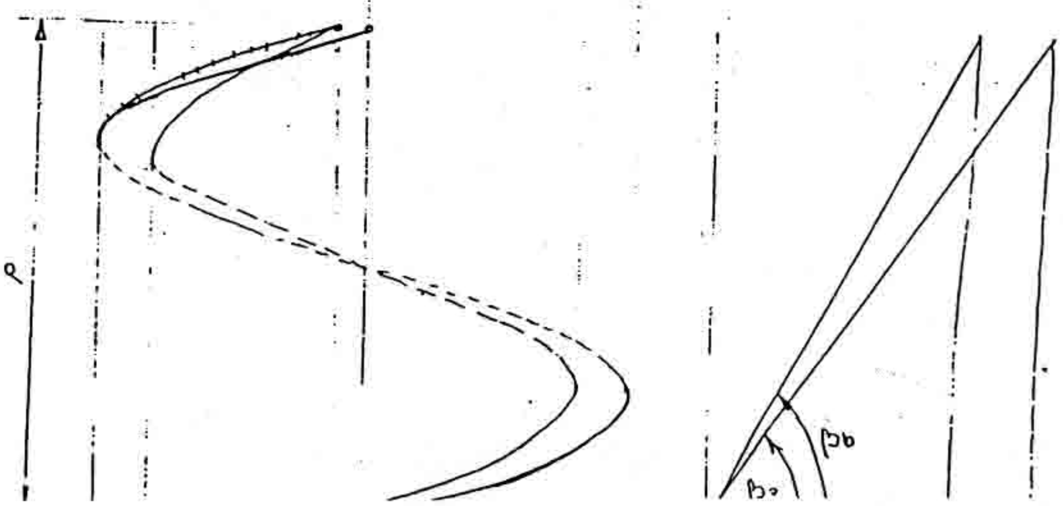
$$\boxed{\frac{d_b}{d_{b\beta}} = \frac{1}{\cos\beta_0} \cdot \frac{\cos\alpha_{0n}}{\cos\alpha_0}}$$

$$tg\,\beta_b = \frac{P}{\pi d_b}$$

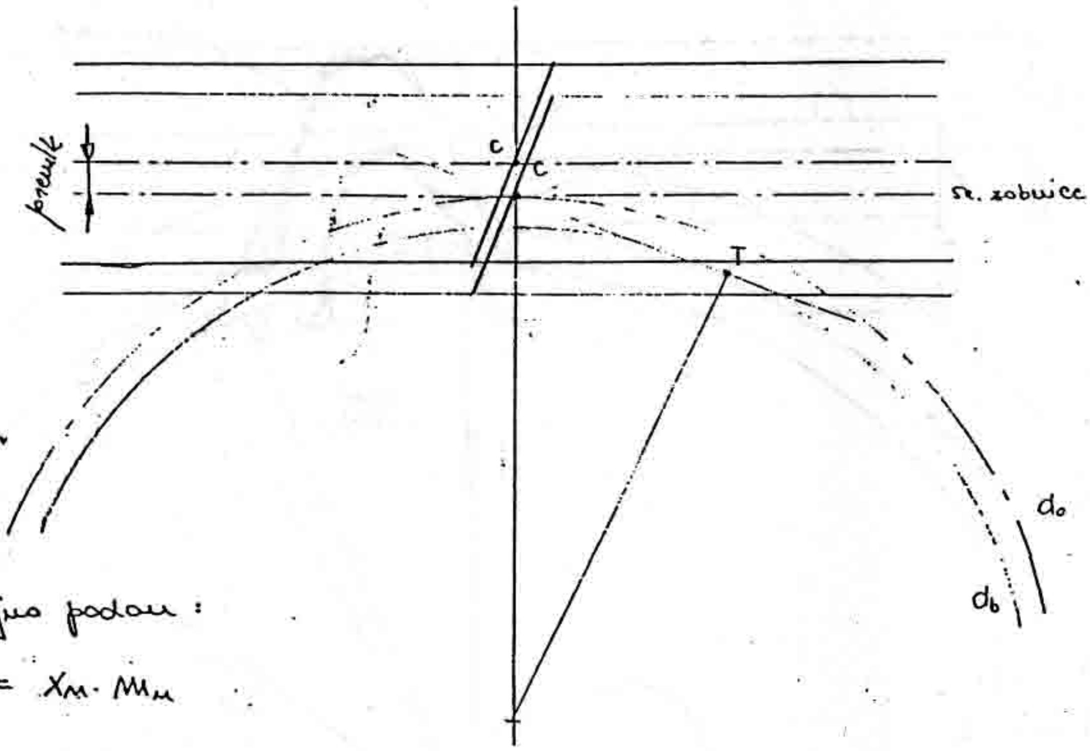
$$tg\,\beta_0 = \frac{P}{\pi d_0}$$

$$tg\,\beta_b = \frac{\pi \cdot d_0 \cdot tg\,\beta_0}{\pi \cdot d_b}$$

$$\boxed{tg\,\beta_b = \frac{tg\,\beta_0}{\cos\alpha_{0n}}}$$

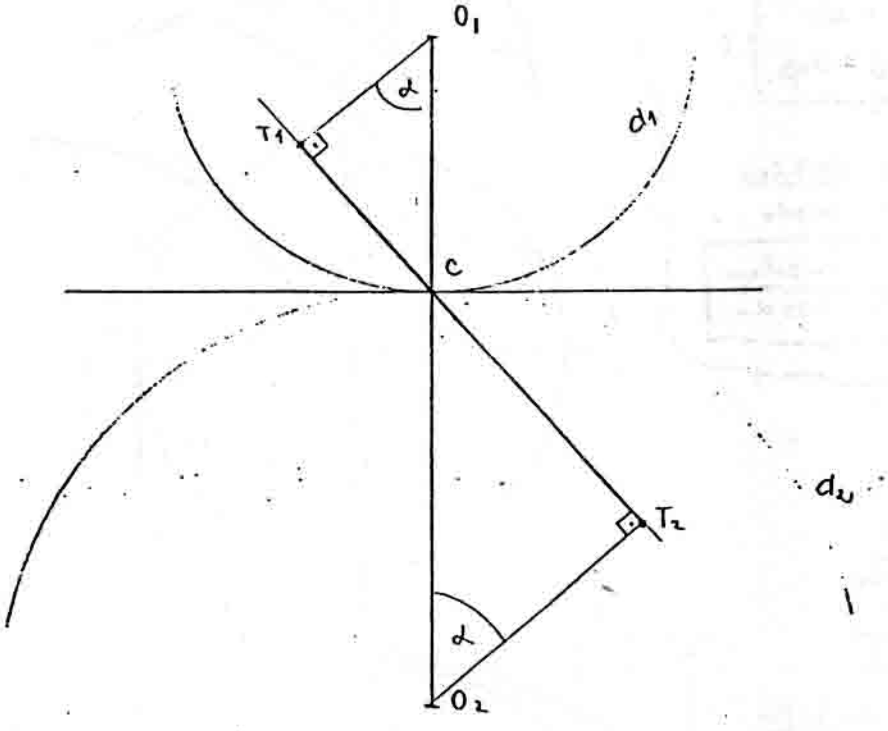


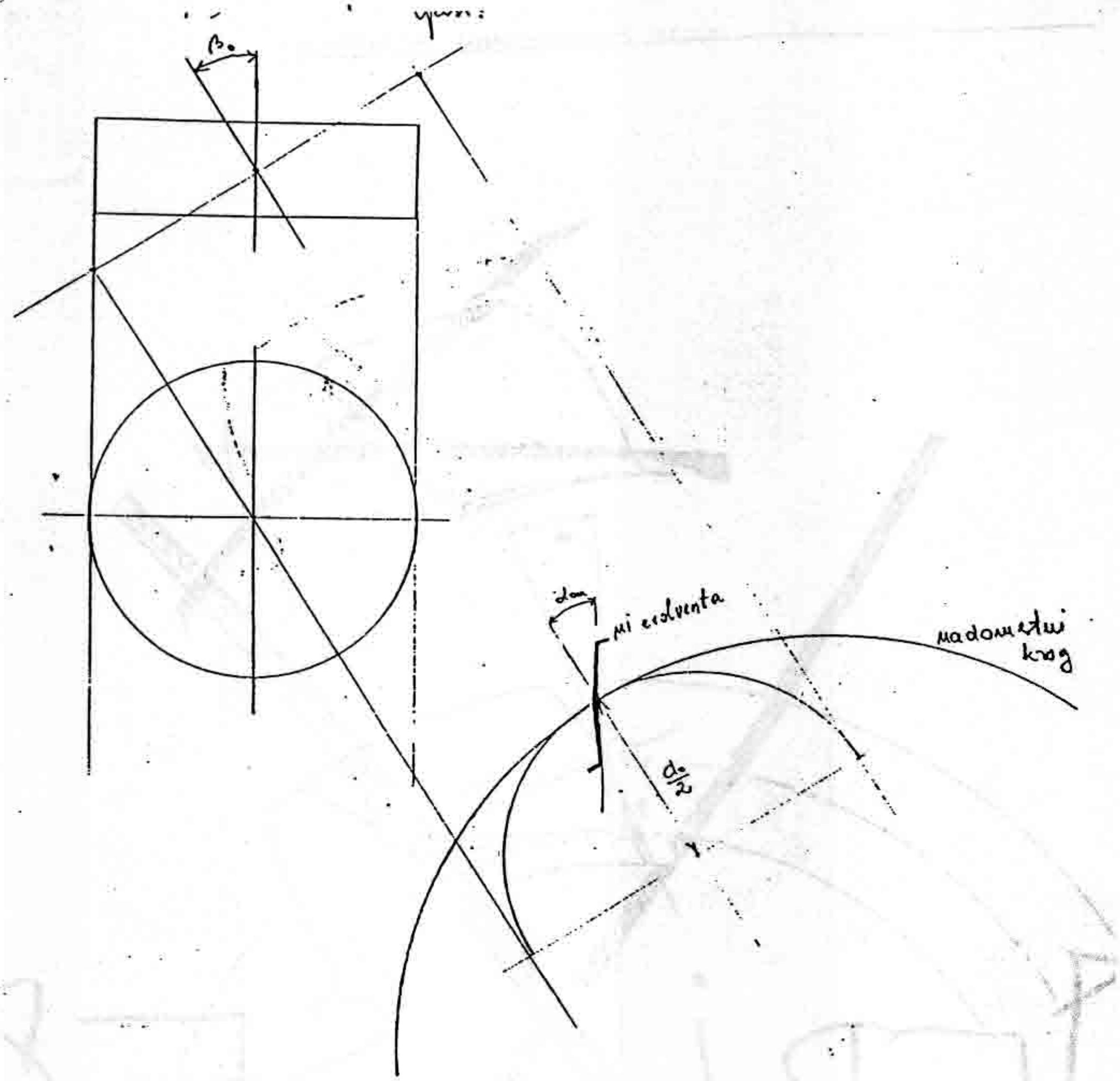
OKRETNICA ČELNEGA KOLESA S POŠEVNIMI ZOBMI:



mit ji običajno podan:

$V = x \cdot m = x_m \cdot m_n$





MEJNO ŠTEVILO ZOB PRI POŠEVNEM ZOBNIKU

$$\overset{x_{min}}{z_{min}} = \frac{14 - z}{17}$$

$z \cdot m_{no} = d_o$ (čelni, ravni zobje)

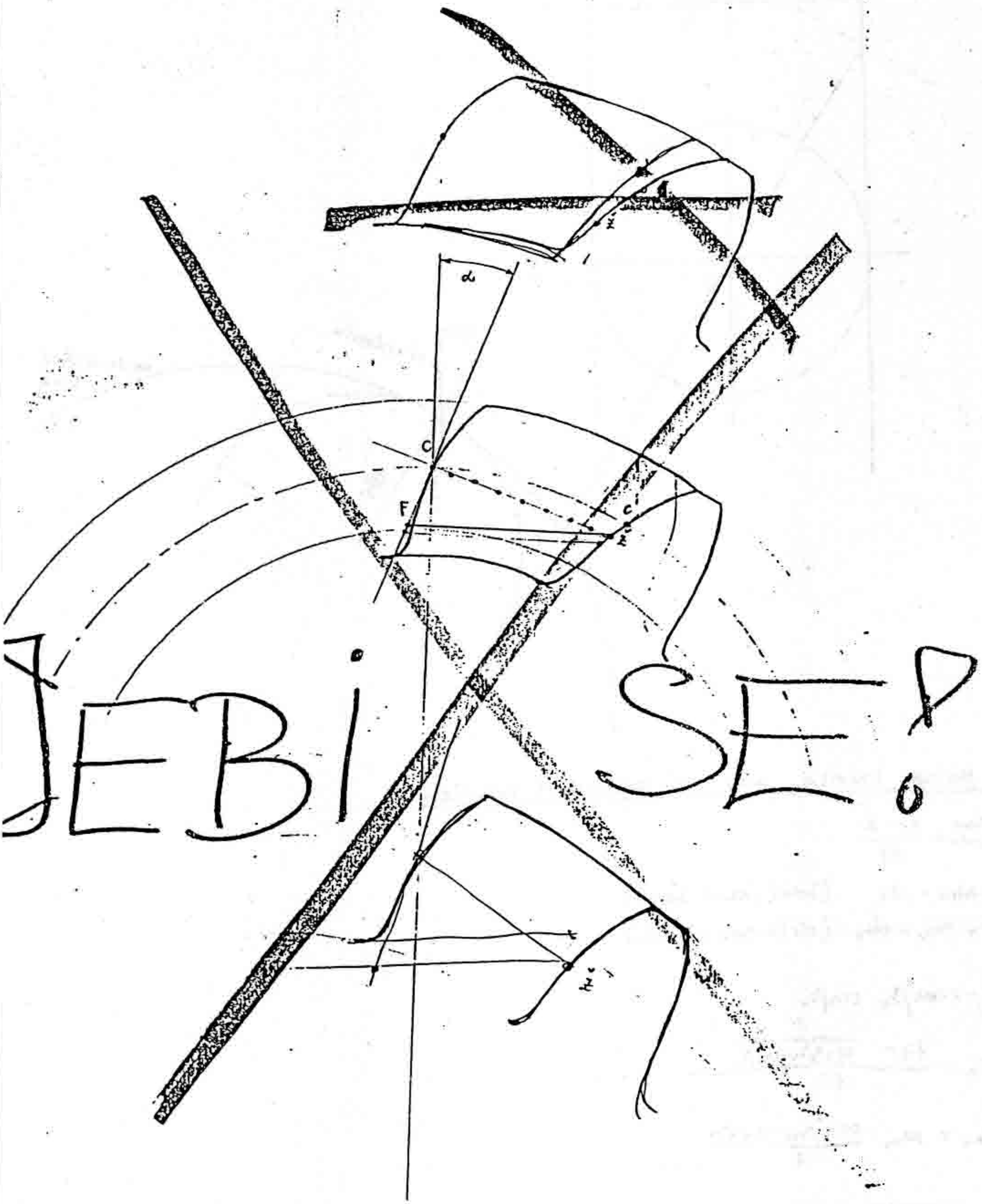
$z_v \cdot m_{no} = d_{ov}$ (virtualni zobnik)

$$\frac{z}{z_v} = \cos^2\beta_b \cdot \cos\beta_o$$

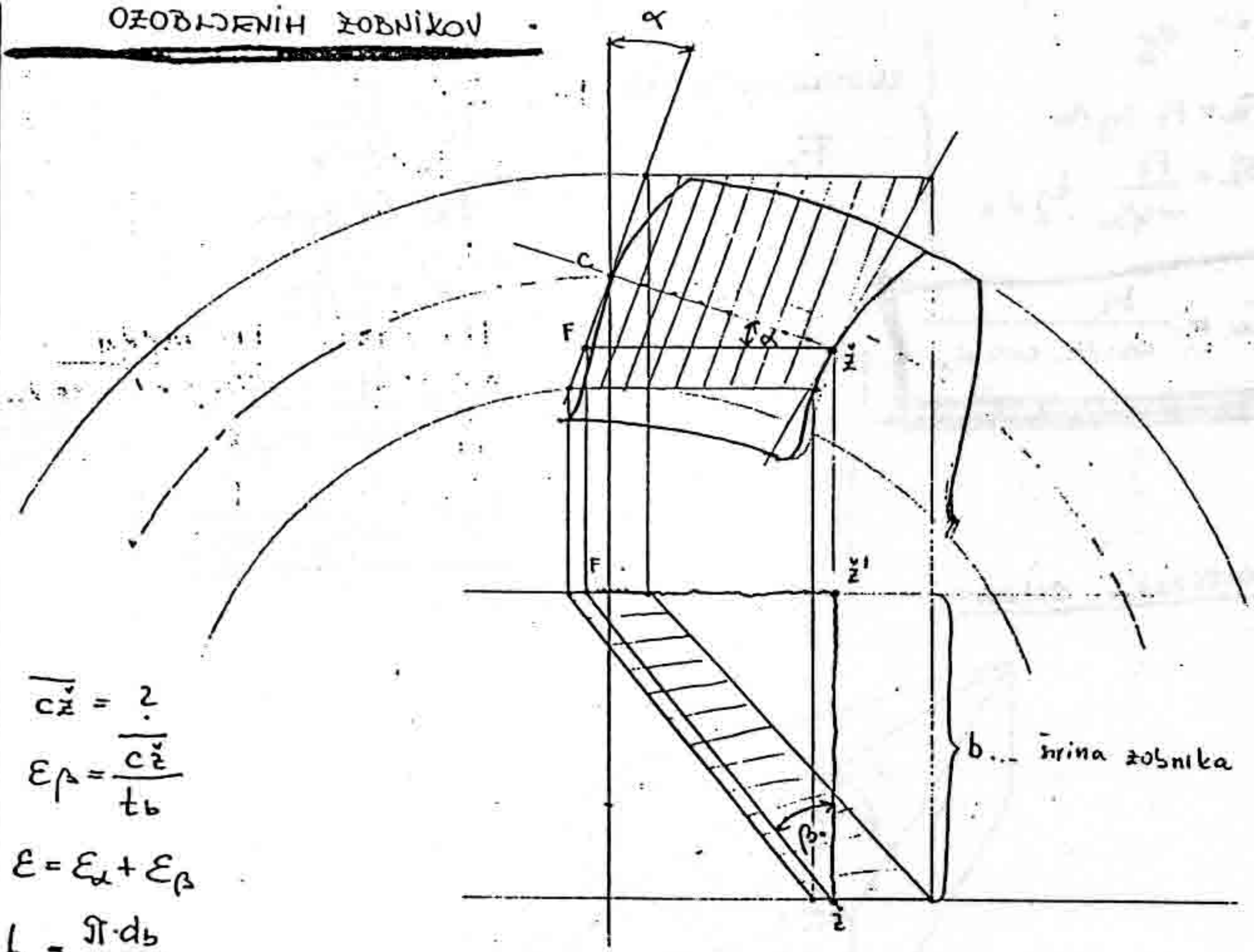
$$x_m = \frac{14 - \frac{z}{\cos^2\beta_b \cdot \cos\beta_o}}{17}$$

$$d_{ov} = m_{no} \cdot \frac{\cos^2\beta_b \cdot \cos\beta_o}{z}$$

$$\boxed{z_{mej} = 17 \cdot \cos^2\beta_b \cdot \cos\beta_o}$$


α
C
F
C
JEBI SE!

OZOBLJENIH ZOBNIKOV .



$\overline{C\check{z}} = ?$

$\varepsilon_\beta = \dfrac{\overline{C\check{z}}}{t_b}$

$\varepsilon = \varepsilon_\alpha + \varepsilon_\beta$

$t_b = \dfrac{\pi \cdot d_b}{z}$

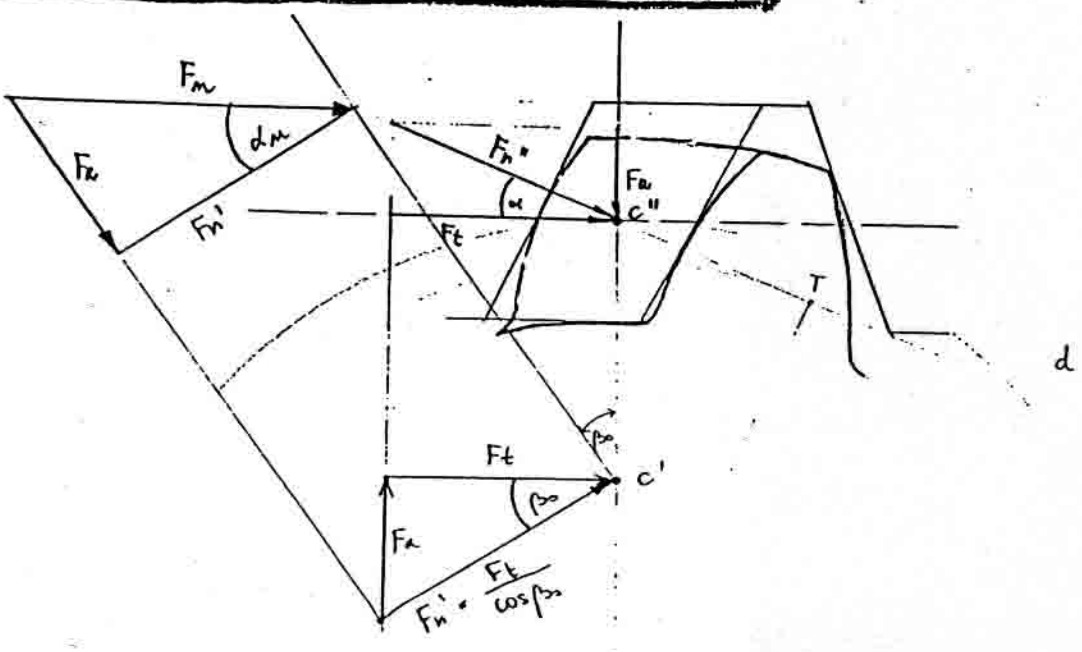
$\overline{F\check{z}'} = \overline{F\check{z}}$

$\overline{F\check{z}} = b \cdot tg\beta_0$

$\overline{C\check{z}} = \overline{F\check{z}} \cdot \cos\alpha$

$$\boxed{\varepsilon_\beta = \frac{b \cdot tg\beta_0 \cdot \cos\alpha}{t_b}}$$

* SILE PRI POŠEVNO OZOBLJENEM ZOBNIKU



$r = \frac{d}{2}$

$F_a = F_t \cdot tg\,\beta_0$

$F_R = \frac{F_t}{\cos\beta_0} \cdot tg\,\alpha_M$

REZULTANTA JE F_M

$F_M = \frac{F_R}{\sin\alpha_M}$

$F_R = F_M' \cdot tg\,\alpha_M$

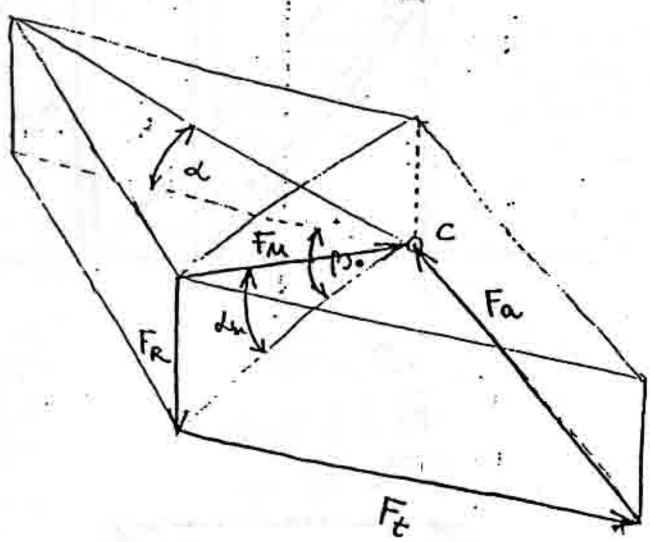
$F_M' = \frac{F_t}{\cos\beta_0}$

$F_M = \frac{F_t \cdot tg\,\alpha_M}{\cos\beta_0 \cdot \sin\alpha_M} = \frac{F_t \cdot \cancel{\sin\alpha_M}}{\cos\beta_0 \cdot \cancel{\sin\alpha_M} \cdot \cos\alpha_M}$

$$\boxed{F_M = \frac{F_t}{\cos\beta_0 \cdot \cos\alpha_M}}$$

$$\boxed{F_M = \frac{F_t}{\cos\beta_0 \cdot \cos\alpha_M}}$$

PROSTORSKA SLIKA:

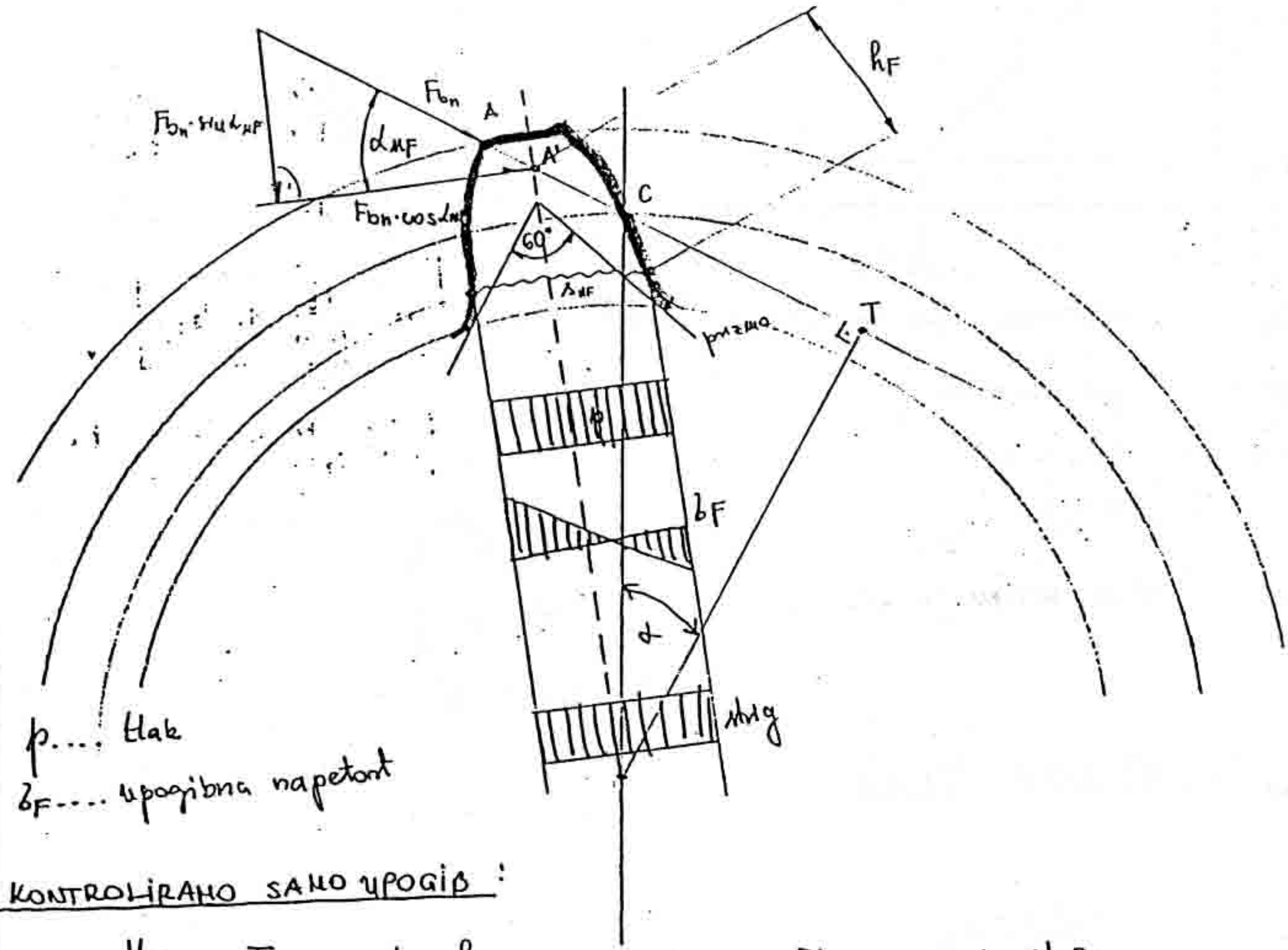


PR. ZA KOLOKVIJ:

SILE NA POŠEVNI ZOBNIK, ČE JE ZNANA OBODNA SILA, ALI PA PRITISNA SILA.

IZRAČUN ČELNIH ZOBNIKOV PO

1, KORENSKA TRDNOST: DIN 3990



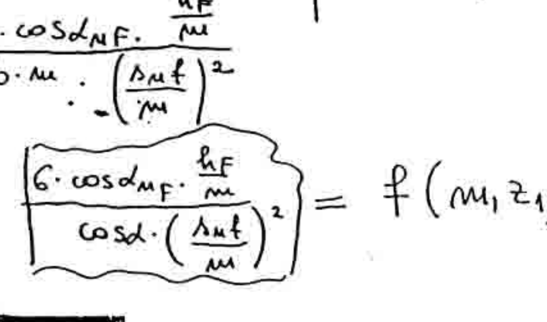
p.... tlak

σ_F.... upogibna napetost

KONTROLIRAMO SAMO UPOGIB:

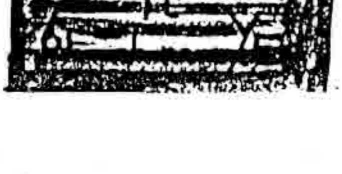
$$\sigma_F = \frac{M_{up}}{W} = \frac{F_{bn}\cdot\cos\alpha_{NF}\cdot h_F}{\frac{b\cdot s_{NF}^2}{6}}$$

b .... širina zobnika

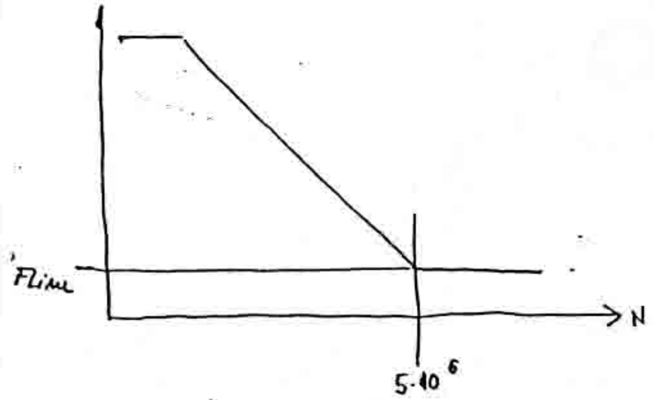


$$\sigma_F = \frac{Ft}{\cos\alpha}\cdot\frac{6\cdot\cos\alpha_{NF}\cdot\frac{h_F}{m}}{b\cdot m\cdot\left(\frac{s_{NF}}{m}\right)^2}$$

$$\sigma_F = \frac{Ft}{b\cdot m}\cdot\underbrace{\boxed{\frac{6\cdot\cos\alpha_{NF}\cdot\frac{h_F}{m}}{\cos\alpha\cdot\left(\frac{s_{NF}}{m}\right)^2}}}_{Y_F} = f(m, z_1, z_2, i, x_1, x_2)$$



σ_{Flim} je neke vrste ekvivalenca z trajno dinamično trdnostjo



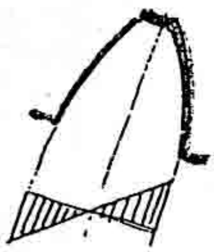
k_{FA} ... korekturni faktor, ki je $f(m)$

$k_{FA} = 1$ pri $m = 10$

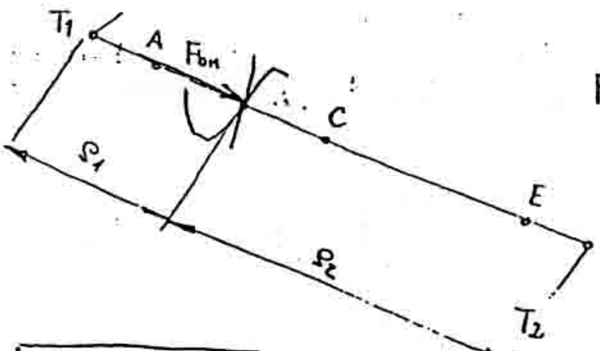
$m < 10$ je $k_{FA} < 1$

$k_{FA} \rightarrow 0{,}75$

k_{FK} .... faktor zarezanega učinka



II. HERTZOV TLAK



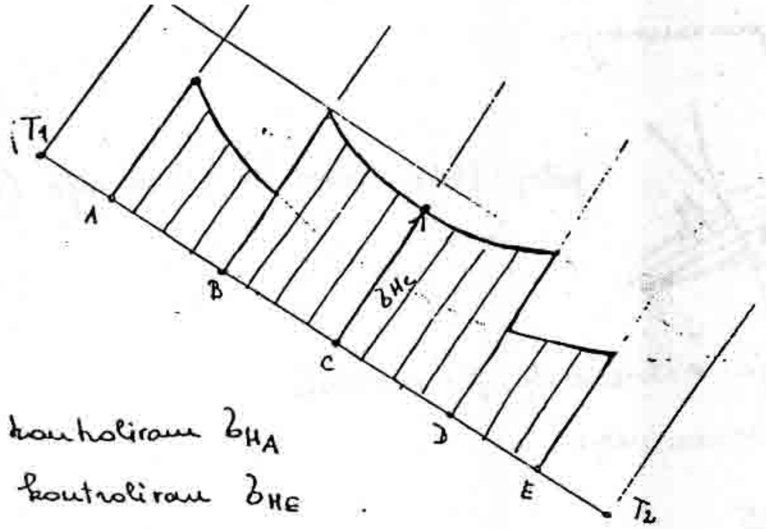
F_{bn}.... obremenitev v smeri ubočnice

$$\sigma_H = \sqrt{\frac{F_{bn}\cdot E_{sr}}{2\pi b\cdot(1-\nu^2)\cdot\rho}}$$

$$\frac{2}{E_{sr}} = \frac{1}{E_1} + \frac{1}{E_2}$$

$\nu \rightarrow \nu_1$ in ν_2 (Poissonovo število)

$$\frac{1}{\rho} = \frac{1}{\rho_1} \pm \frac{1}{\rho_2}$$



$z_1 < 20$ kontroliram σ_{HA}

$z_2 < 20$ kontroliram σ_{HE}

kontrola c:

$$\rho_{1c} = r_1 \cdot \sin\alpha$$
$$\rho_{2c} = r_2 \cdot \sin\alpha$$
$$\rho = \frac{\rho_c}{\cos\beta_b}$$

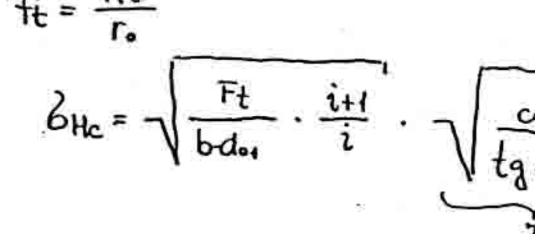
$$F_t = F_{bn} \cdot \cos\alpha$$
$$F_t = \frac{M_t}{r_0}$$

$$\sigma_{Hc} = \sqrt{\frac{F_t}{b \cdot d_{01}} \cdot \frac{i+1}{i}} \cdot \underbrace{\sqrt{\frac{\cos\beta_b}{tg\,\alpha \cdot \cos^2\alpha_0}}}_{Z_H} \cdot \underbrace{\sqrt{\frac{2}{\pi \cdot \left(\frac{1-\nu_1^2}{E_1} + \frac{1-\nu_2^2}{E_1}\right)}}}_{Z_M}$$

$$\sigma_{Hc} = \sqrt{\frac{F_t}{b \cdot d_{01}} \cdot \frac{i+1}{i}} \cdot Z_H \cdot Z_M \cdot Z_\varepsilon \cdot \underbrace{\sqrt{k_{H\alpha} \cdot k_{H\beta} \cdot k_I \cdot k_v}}_{\text{faktorji, ki vplivajo na velikost sile}}$$

$$\sigma_{Hc} \leq \sigma_{Hdop}$$

$$\sigma_{H\,dop} = \frac{\sigma_{Hlim} \cdot Z_R \cdot Z_v \cdot k_L}{S_H}$$



$Z_\varepsilon = y_\varepsilon$

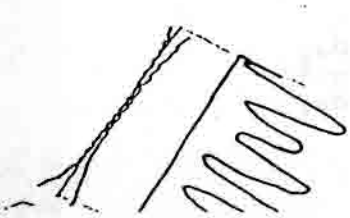
$k_{H\alpha} = k_{F\alpha}$

$k_{H\beta} = k_{F\beta}$

k_I .... faktor sunkov

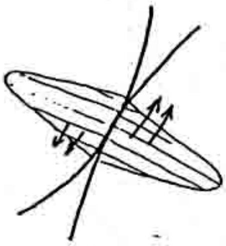
k_v .... faktor notranjih sunkov

Z_R ... faktor hrapavosti in neravnosti



... kojem ... površavanja

$v_{DR} = f(v)$



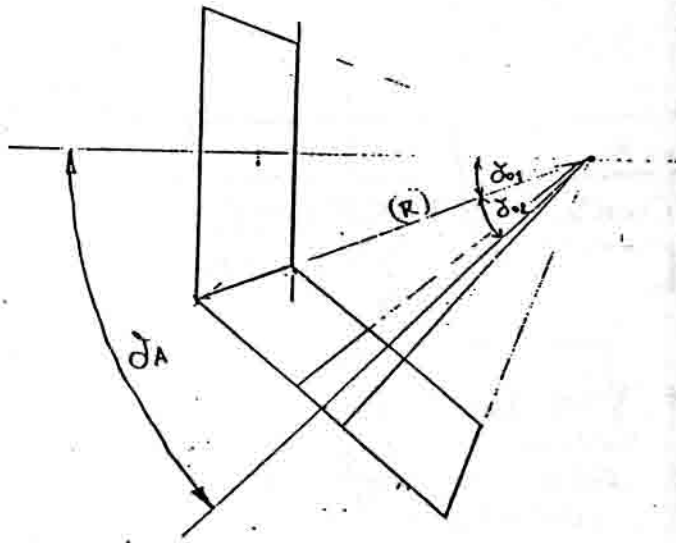
poleg tlaka imamo še zdrsavanje (strig)

Z_L.... funkcija merjenja viskoznosti pri mazivih

Z_H.... odmik sile od vazne meje

$S_H = \sqrt{S_F} \doteq 1,25$

STOŽČASTI ZOBNIKI



$$i = \frac{d_{02}}{d_{01}} = \frac{z_2}{z_1}$$

$$\delta_{01} + \delta_{02} = \delta_A$$

$$\frac{d_{01}}{2} = R \cdot \sin \delta_{01}$$

$$\frac{d_{02}}{2} = R \cdot \sin \delta_{02}$$

$$\frac{d_{02}}{d_{01}} = i = \frac{\sin \delta_{02}}{\sin \delta_{01}}$$

če je $\delta_A = 90°$

$$\frac{d_{01}}{2} = R \cdot \sin \delta_{01}$$

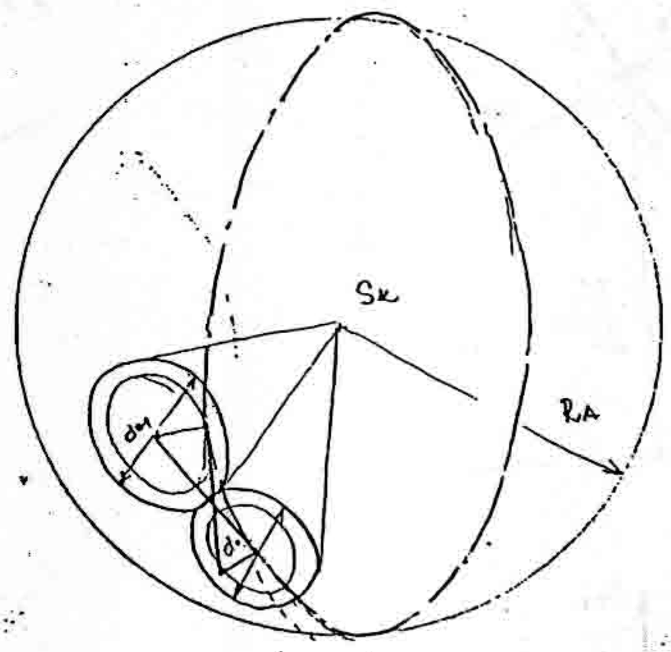
$$\frac{d_{02}}{2} = R \cdot \sin (90 - \delta_{01})$$

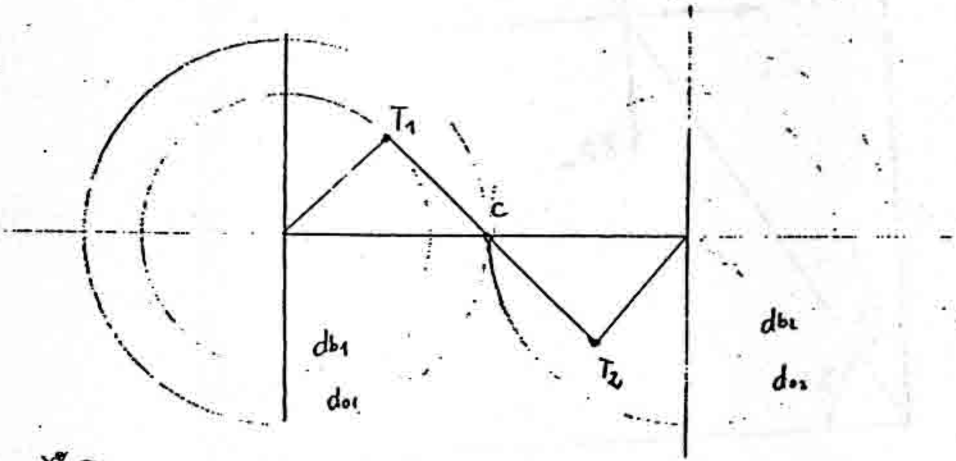
$$= R \cdot \left[\sin 90 \cdot \cos \delta_{01} - \cos 90 \cdot \sin \delta_{01} \right]$$

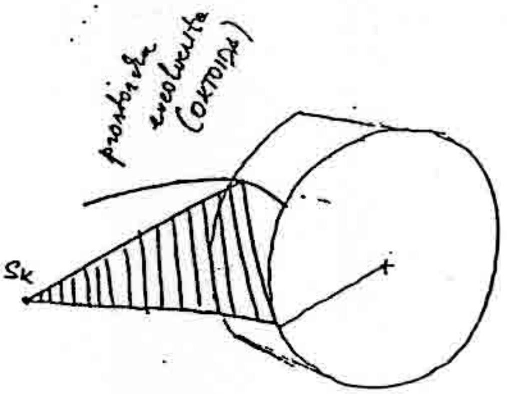
$$= R \cdot \cos \delta_{01}$$

$$i = \frac{d_{02}}{d_{01}} = \frac{2R \cos \delta_{01}}{2R \sin \delta_{01}} = \frac{1}{\frac{\sin \delta_{01}}{\cos \delta_{01}}}$$

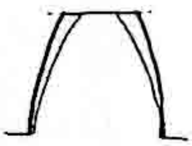
$\boxed{:\ 1}$



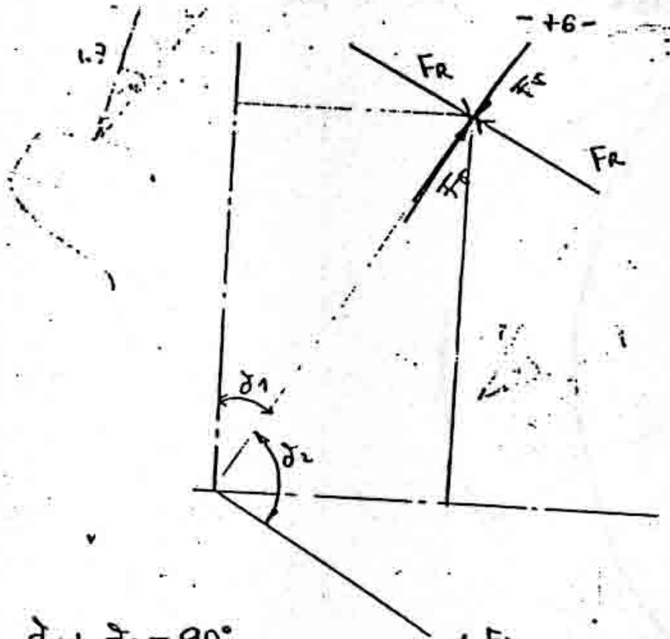




oblika zoba pri stožčastem zobniku



zobji so zgoraj močnejši



$\bar{u}$ $\dot{g}$: $\gamma_1 + \gamma_2 = 90°$