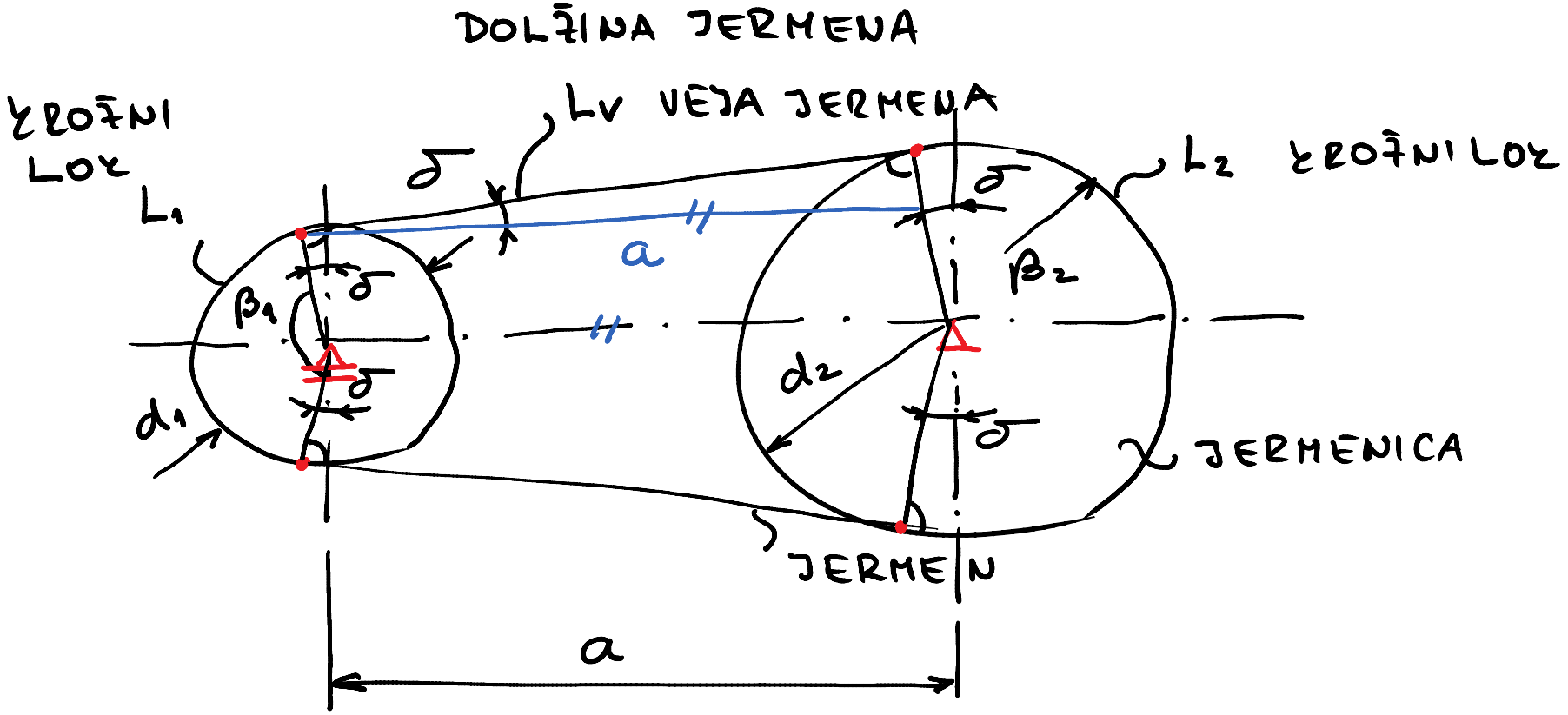
# JERMENSKA GONILA

JERMENE DELIMO V : PLOŠČATE
KLINASTE
ZOBATI

NAČIN PRENOSA MOČI : S TRENJEM
Z OBLIZO

+ ENOSTAVNA KONSTRUKCIJA
+ PREPROSTO VZDRŽEVANJE
+ BLAŽENJE VIBRACIJ
+ VAROVANJE PRED PREOBREMENITVIJO
+ MOŽNE VELIKE MEDOSNE RAZDALJE
+ Z ENIM JERMENOM LAHKO POGANJAMO VEČ GREDI
- ZDRS V PRIMERU PRENOSA MOČI S TRENJEM
- HRUP V PRIMERU PRENOSA MOČI Z OBLIZO
- OBČUTLJIVOST NA VPLIVE IZ OKOLJA

– OBREMENITEV GREDI




$a$ MEDOSNI RAZMIK $\beta_1$ IN $\beta_2$ OBJEMNI KOT

$d_1$ IN $d_2$ PREMERA JERMENIC NA NEUTRALNI OSI

$$L = L_1 + L_2 + 2L_v$$

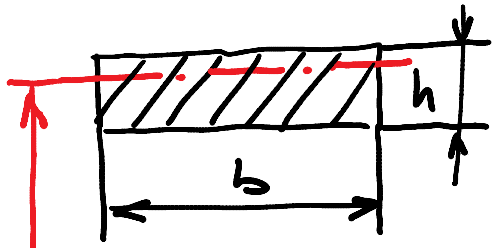
$$L_1 = \hat{\beta}_1 \frac{d_1}{2} \qquad L_2 = \hat{\beta}_2 \frac{d_2}{2}$$

$$\hat{\beta}_1 = \pi - 2\hat{\delta} \qquad \hat{\beta}_2 = \pi + 2\hat{\delta}$$

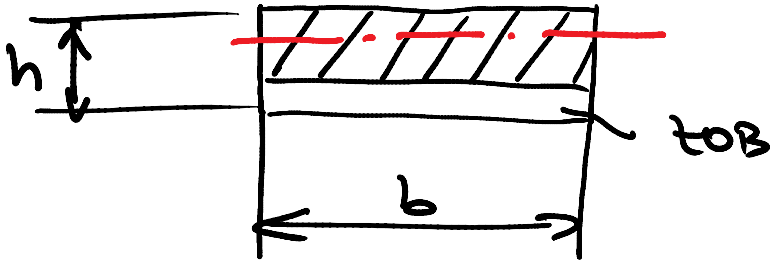
$$tg\,\delta = \frac{d_2 - d_1}{2L_v} \qquad L_v = \frac{d_2 - d_1}{2\,tg\,\delta}$$

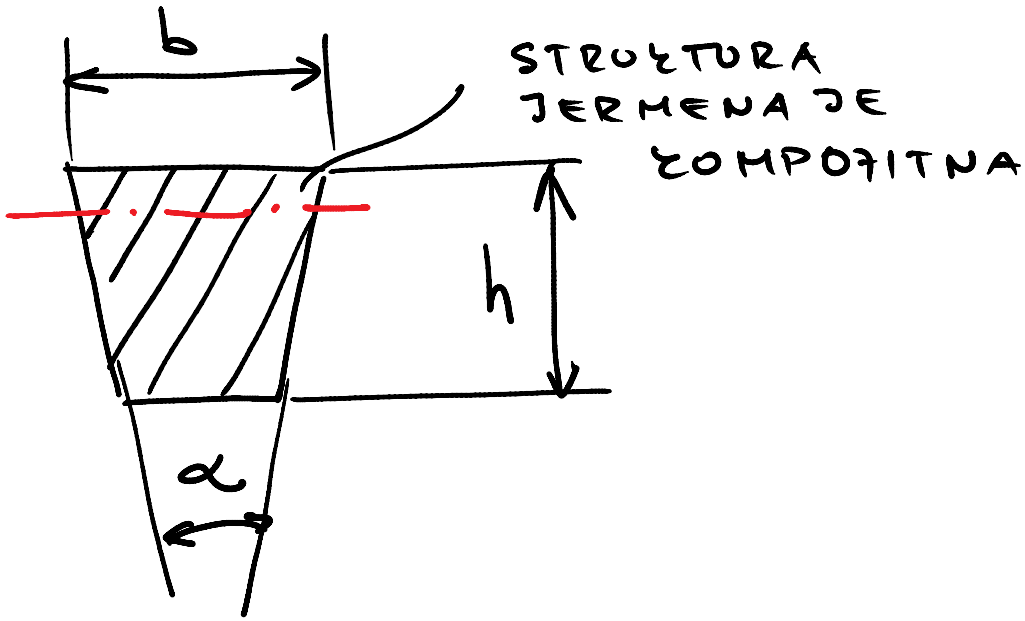
$$L = \frac{\hat{\beta}_1 d_1}{2} + \frac{\hat{\beta}_2 d_2}{2} + \frac{d_2 - d_1}{tg\,\delta}$$

$$\check{d}_1, \check{d}_2, \check{\alpha} \qquad \sin\delta = \frac{d_2 - d_1}{2a}$$

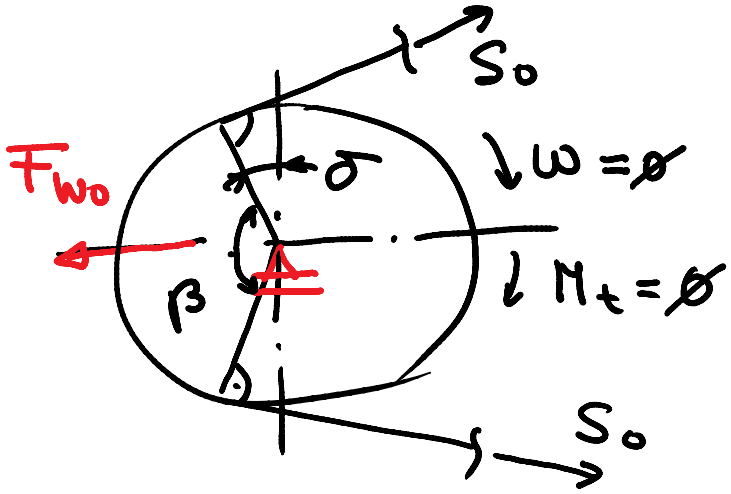


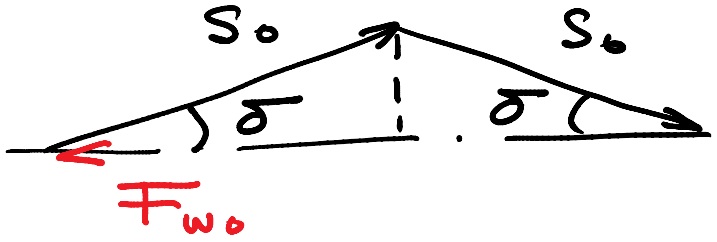

$a_1, a_2$ SE MERITA OD NEUTRALNE OSI JERMENA



## SILA PREDNAPETJA PRI MONTAŽI

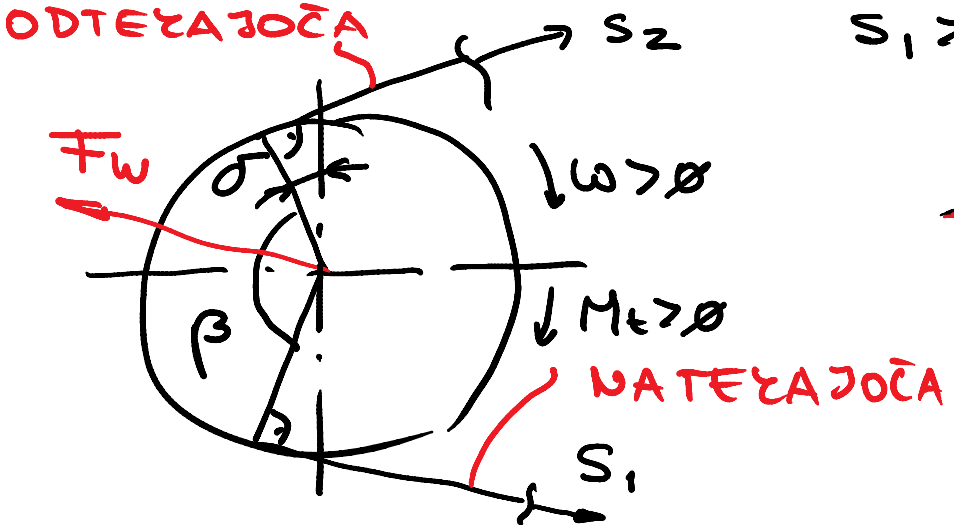


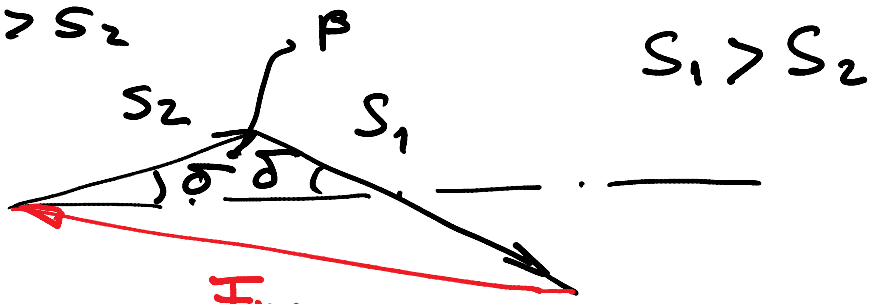

$$F_{W0} = 2 S_0 \cos\delta$$

## SILA PREDNAPETJA PRI OBRATOVANJU

ODTEŽAJOČA



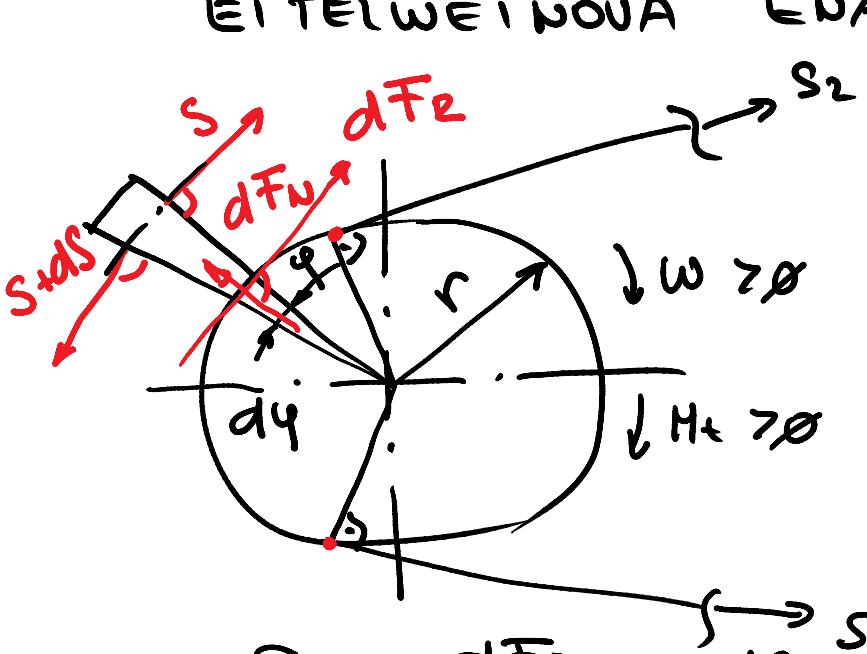

$S_1 > S_2$

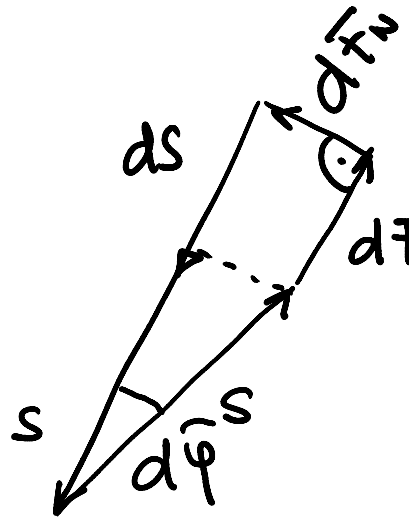



$S_1 > S_2$

$$F_W = \sqrt{S_1^2 + S_2^2 - 2 S_1 S_2 \cos\beta}$$

# EITELWEINOVA ENAČBA




$$dF_R = \mu\, dF_N$$

$$S\, d\varphi \cong dF_N$$

$$dS \cong dF_R$$

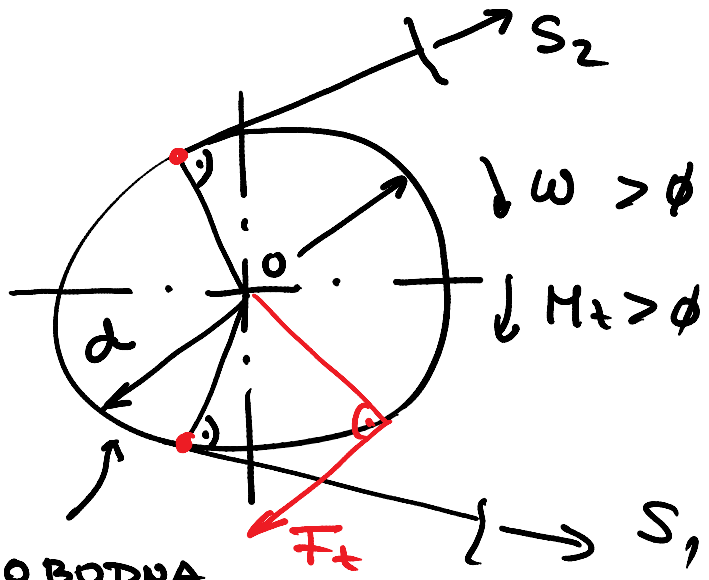
$$S\, d\varphi = \frac{dF_R}{\mu} = \frac{dS}{\mu}$$

$$\int_0^{\hat{\beta}} \mu\, d\varphi = \int_{S_2}^{S_1} \frac{dS}{S}$$

$$\mu\hat{\beta} = \ln S \Big|_{S_2}^{S_1} = \ln \frac{S_1}{S_2}$$

$$S_1 = S_2 \cdot e^{\mu\hat{\beta}} = S_2 \cdot m$$

m: RAZMERJE SIL




OBODNA SILA SE PRENAŠA ZOT „INTEGRAL" PREZO ZONTAKTA JERMENA IN JERMENICE

$$\sum M_i^{\circ} = \phi = S_2 \cdot r - S_1 r + F_t r \mid :r$$

$$F_t = S_1 - S_2$$

$M_t \vee$

$$F_t = \frac{M_t}{r} \vee$$

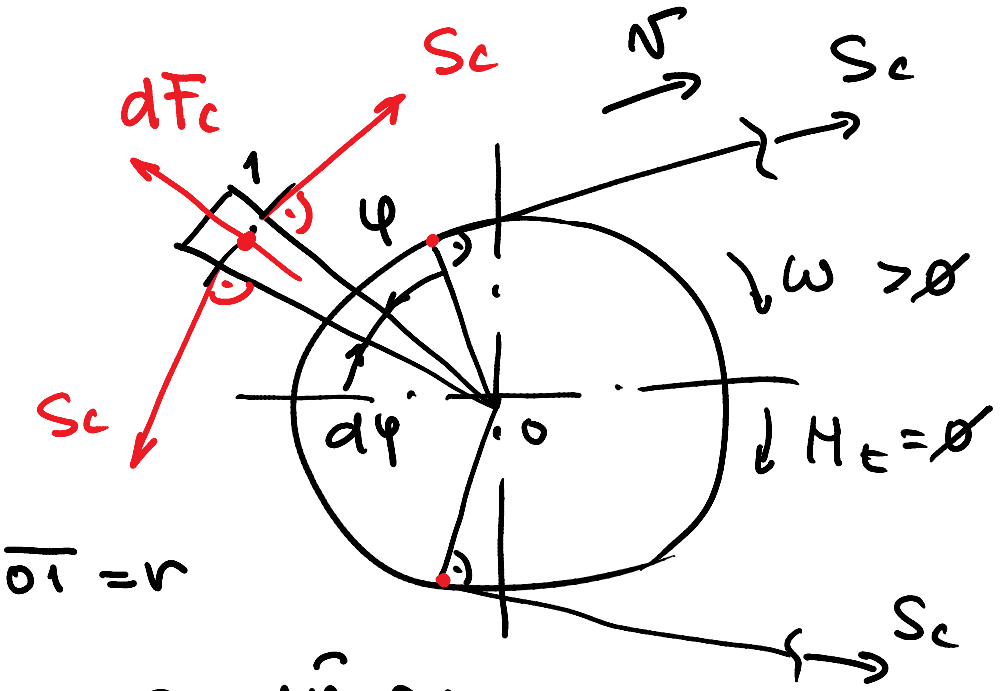
EITELWEINOVA ENAČBA OBRAUNAVA RAZMERE NA MEJI ZDRSA

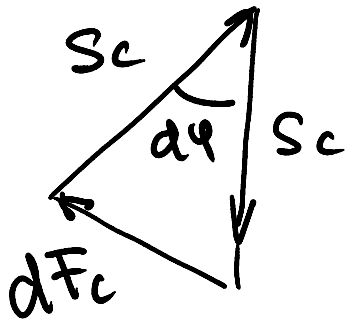
$F_R = F_t$.

$\frac{S_1}{S_2} > m$ ELASTIČNI IN PRAVI ZDRS

$\frac{S_1}{S_2} \leq m$ ELASTIČNI ZDRS

# UPLIV CENTRIFUGALNE SILE NA SILE U JERMENU




$$dm = \rho\, dV = \rho A r\, d\varphi$$

$$S_c\, d\varphi \cong dF_c = r\,\omega^2\, dm$$

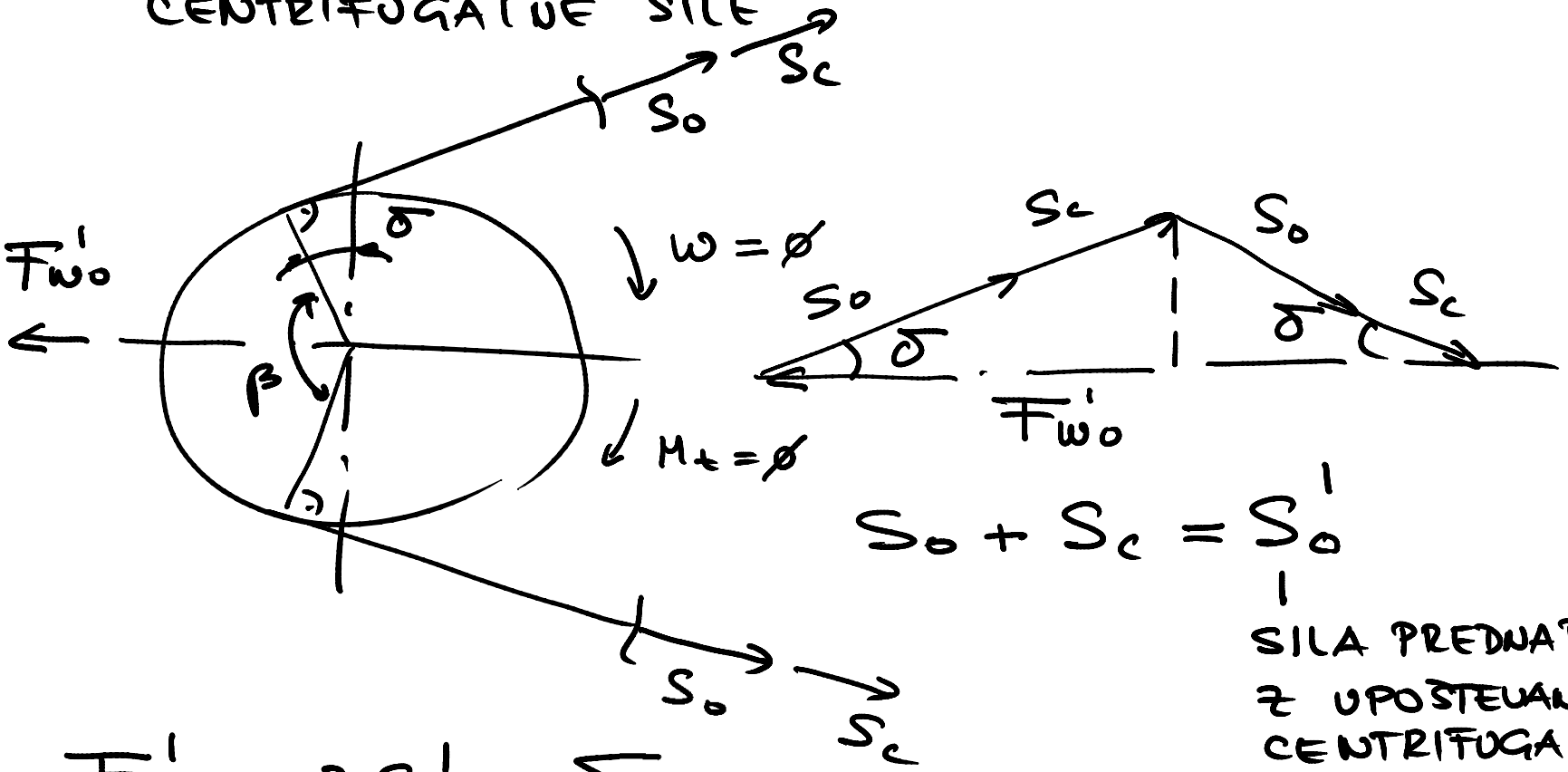
$$S_c\, d\varphi = r\,\omega^2\, \rho A r\, d\varphi$$

$v$: OBODNA HITROST JERMENA

$$S_c = \rho A v^2$$

SILA U JERMENU ZBOG CENTRIFUGALNE SILE

SILA PREDNAPETJA PRI MONTAŽI Z UPOŠTEVANJEM CENTRIFUGALNE SILE




$$S_0 + S_c = S_0'$$

$S_0'$ – SILA PREDNAPETJA Z UPOŠTEVANJEM CENTRIFUGALNE SILE

$$F'_{w0} = 2 S_0' \cos\delta$$

$\omega = \emptyset$ : $S_0 + S_c$

$\omega > \emptyset$ : $S_0$

$\omega > \emptyset$ : $S_0' + S_c$

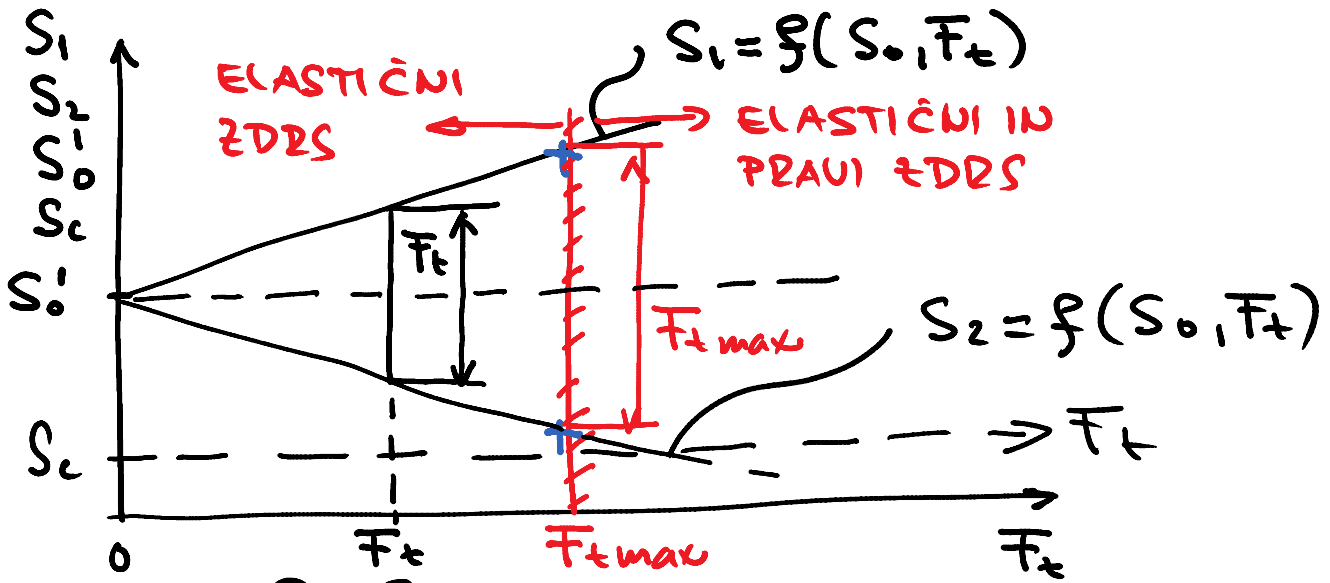
$\omega = \emptyset$ : $S_0'$

SE WA NASA NA GRED

SE WANASA NA JERMEN

ZGORAJ NAVEDENO VELJA ZA $M_t = \emptyset$

# VPLIV OBODNE SILE NA SILE V JERMENU




$m = 1{,}5$

$S_c = 300\,N$

$F_{t\,max} = 1500\,N$

D. N.

$$S_0 = \frac{S_1 + S_2}{2} \qquad F_t = S_1 - S_2$$

$$S_1 = S_1(S_0, F_t) = ?^2$$

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

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

DIAGRAM VELJA, ČE JERMEN NAPENJAMO S TOMILANJEM JERMENICE.

$$S_2 = S_2(S_0, F_t) = ?$$

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

$$S_2 = S_0 - \frac{F_t}{2}$$

NAJVEČJA OBODNA SILA, KI JO ŽELIMO PRENAŠATI! TO SILO POIŠČEMO.

$$S_1 = S_2 \cdot m \qquad F_{t\,max} = S_1 - S_2$$

$$S_1 = S_1(F_{t\,max}) = ?$$

$$S_1 = (S_1 - F_{t\,max}) \cdot m$$

$$S_1(1 - m) = -F_{t\,max}\, m$$

$$S_1 = F_{t\,max} \frac{m}{m-1}$$

$$S_2 = S_2(F_{t\,max}) = ?$$

$$S_2 = \frac{S_1}{m} = \frac{F_{t\,max} + S_2}{m}$$

$$S_2\left(1 - \frac{1}{m}\right) = \frac{F_{t\,max}}{m}$$

$$S_2 = \frac{F_{t\,max}}{m-1}$$

$$S_0' = \frac{S_1+S_2}{2} + S_c = \frac{1}{2} F_{t\,max}\left(\frac{m}{m-1} + \frac{1}{m-1}\right) + S_c$$

$$S_0' = \frac{F_{t\,max}}{2}\,\frac{m+1}{m-1} + \rho A v^2$$

$S_0$

MINIMALNA POTREBNA SILA PREDNAPETJA, ČE JE $F_{t\,max}$ MAKSIMALNA PRIČAKOVANA OBODNA SILA.

POTEK IZRAČUNA

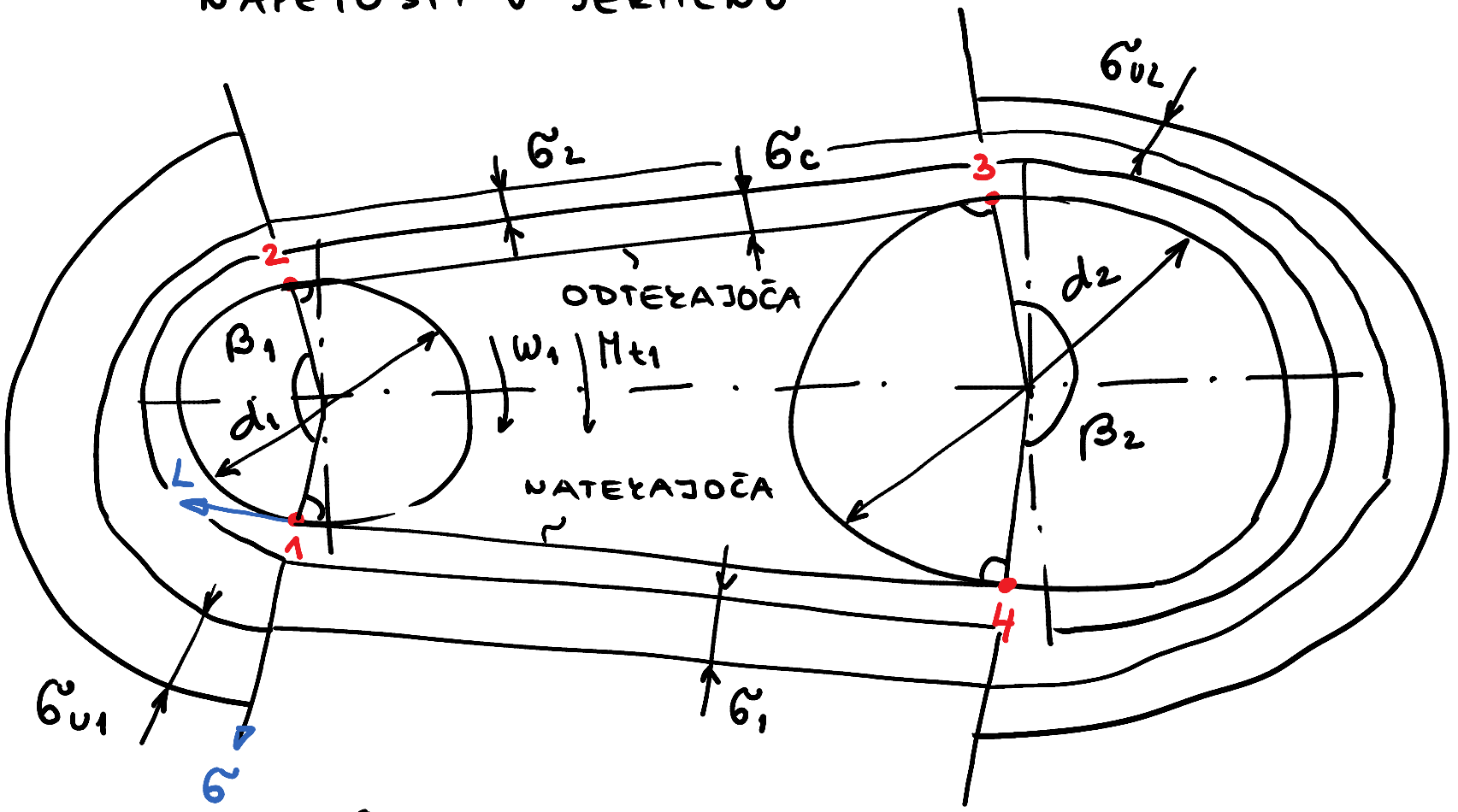
$F_{t\,max}$ ✓ → $S_1$, $S_2$ → $F_w$

$\rho$, $A$, $v$ ✓ → $S_c$ → $F_{w0}$ in $F_{w0}'$

$F_{t\,max}$ ✓ → $S_0$

$S_c$
$S_0$ → $S_0'$

# NAPETOSTI V JERMENU




$$\sigma_{max} = \sigma_1 + \sigma_c + \sigma_{U1}$$

NAPETOST ZARADI CENTRIFUGALNE SILE

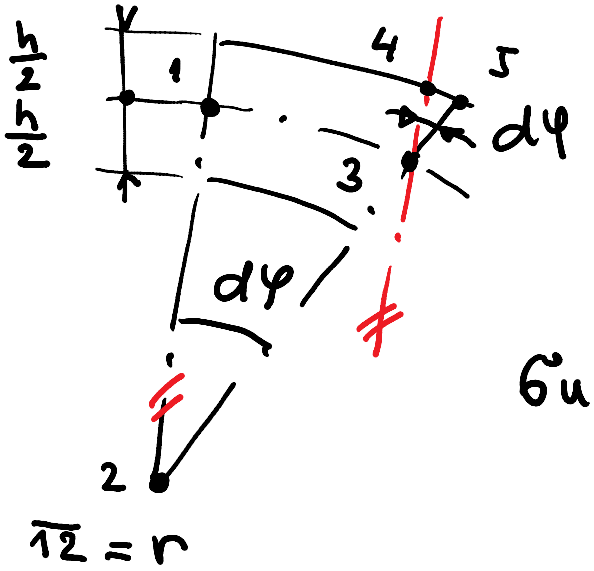
$$\sigma_c = \frac{S_c}{A} = \rho v^2$$

A PREREZ JERMENA

NAPETOSTI ZARADI SIL $S_1$ IN $S_2$ V VEJAH JERMENA

$$\sigma_1 = \frac{S_1}{A} \quad ; \quad \sigma_2 = \frac{S_2}{A}$$

UPOGIBNI NAPETOSTI



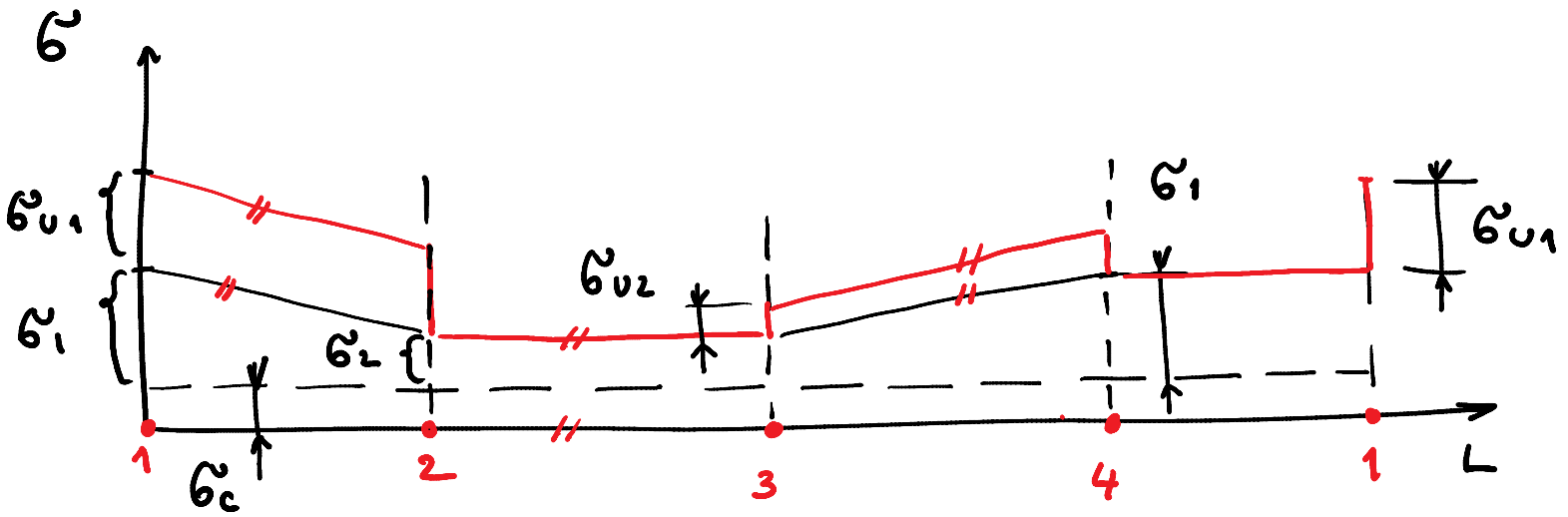

$$dL = r \cdot d\varphi = \widehat{13}$$

$$ddL = \frac{h}{2} d\varphi = \widehat{45}$$

$$\varepsilon_u = \frac{ddL}{dL} = \frac{h\,d\varphi}{2\,r\,d\varphi} = \frac{h}{d} = \frac{\sigma_u}{E}$$

$$\sigma_{u1} = \frac{Eh}{d_1} \quad ; \quad \sigma_{u2} = \frac{Eh}{d_2}$$

# NAPETOSTI V JERMENU PO DOLŽINI JERMENA




$$\sigma_{max} = \sigma_1 + \sigma_c + \sigma_{v1} \leq \sigma_{dop}$$

ŠTEVILO OBREMENITVENIH CIKLOV JE ENAKO ŠTEVILU JERMENIC PREKO KATERIH TEČE JERMEN. DVA CIKLA!

NATEŽNA NAPETOST V JERMENU ZARADI OBODNE SILE

$$\sigma_{max} = \sigma_1 + \sigma_c + \sigma_{v1} \leq \sigma_{dop}$$

$$S_1 = F_{t\,max} \frac{m}{m-1} \quad | : A \qquad \sigma_1 = \frac{S_1}{A} \; ; \; \sigma_{t\,max} = \frac{F_{t\,max}}{A}$$

$$\sigma_1 = \sigma_{t\,max} \frac{m}{m-1}$$

$$\frac{m}{m-1} \sigma_{t\,max} + \rho v^2 + \sigma_{v1} = \sigma_{dop}$$

$$\sigma_{t\,max} = \frac{m-1}{m} \left( \sigma_{dop} - \rho v^2 - \sigma_{v1} \right)$$

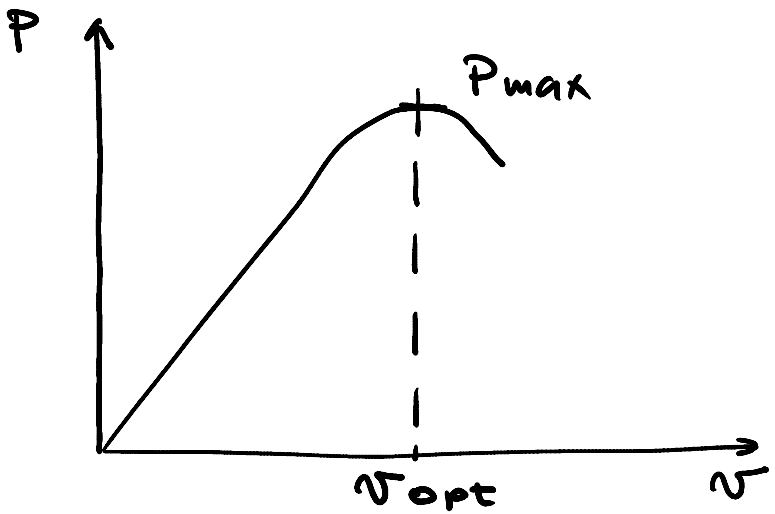
# MOČ IN OPTIMALNA OBODNA HITROST JERMENA

$$P = M_{t\max}\,\omega_1 = F_{t\max}\,\frac{d_1}{2}\,\omega_1 = F_{t\max}\,v$$

$$= \sigma_{t\max}\,A\,v = \frac{m-1}{m}\left(\sigma_{a\,op} - \rho v^2 - \sigma_{u1}\right) A \cdot v$$

$$= \underbrace{\frac{m-1}{m}\left(\sigma_{a\,op} - \sigma_{u1}\right)A}_{C_1} v - \underbrace{\frac{m-1}{m}\rho A}_{C_2} v^3$$

$$P = C_1 \cdot v - C_2 v^3$$

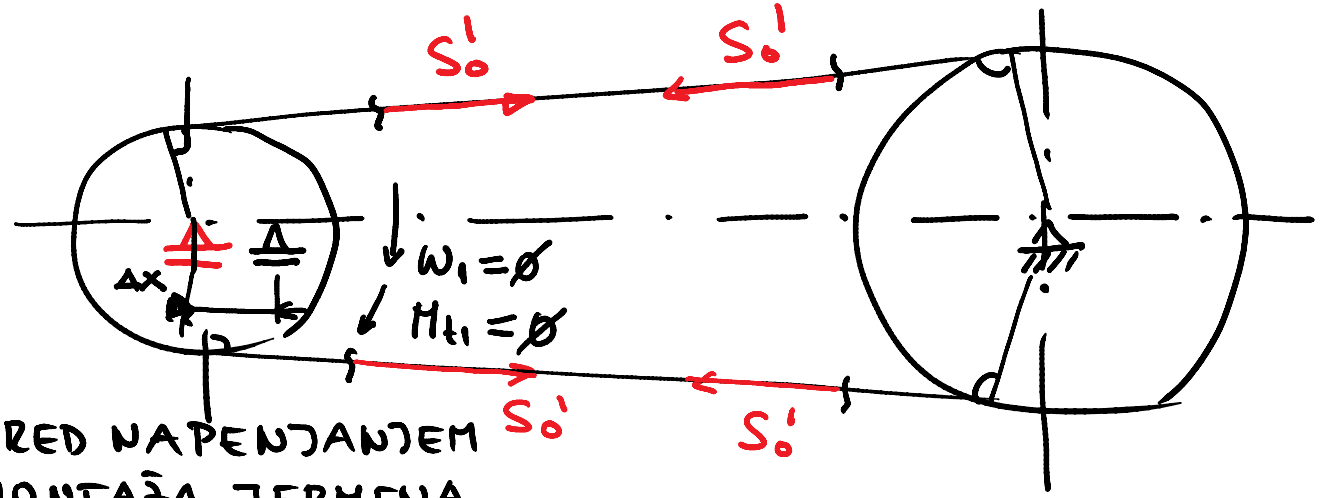



$$\frac{dP}{dv} = C_1 - 3C_2 v_{opt}^2 = 0$$

$$0 = \sigma_{a\,op} - \sigma_{u1} - 3\rho v_{opt}^2$$

$$v_{opt} = \sqrt{\frac{\sigma_{a\,op} - \sigma_{u1}}{3\rho}}$$

# PREDNAPENJANJE JERMENA




$\Delta$ PRED NAPENJANJEM
MONTAŽA JERMENA

$\Delta$ PO NAPENJANJU

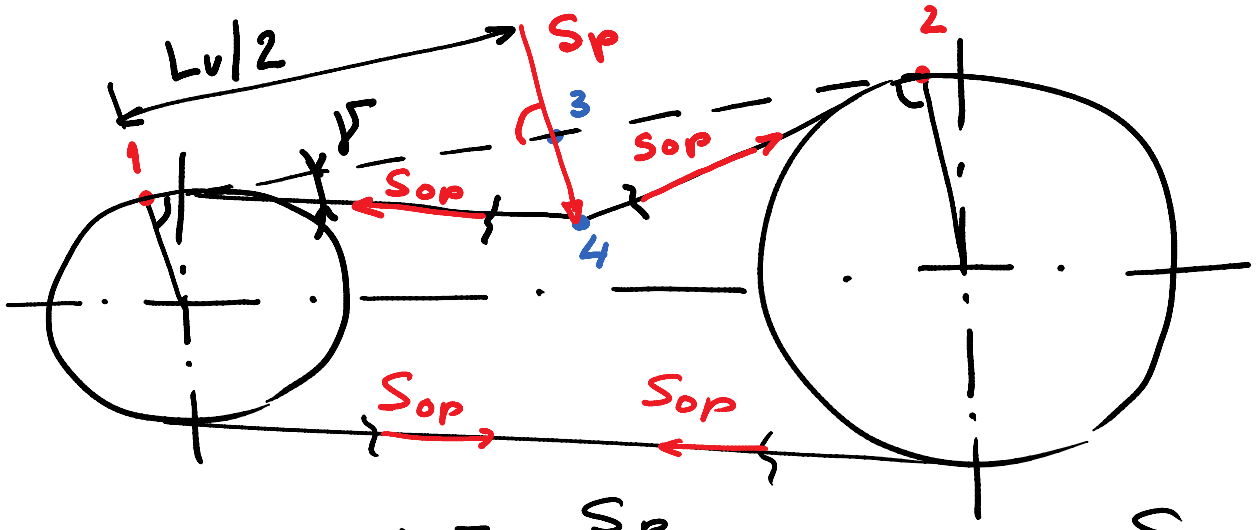
$L$ ZAČETNA DOLŽINA JERMENA

$\Delta L$ RAZTEZEK JERMENA ZARADI $S_0'$

$$\sigma_0 = E \varepsilon_0 \qquad \sigma_0 = \frac{S_0'}{A}$$

$$\varepsilon_0 = \frac{\Delta L}{L}$$

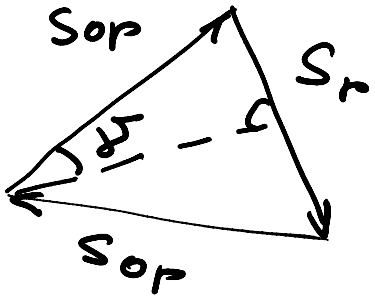
$$S_0' = \frac{AE}{L} \Delta L$$




$$\overline{12} = L_v$$

$$\overline{34} = a$$

$$\overline{14} = \frac{L_v}{2} + \frac{\Delta L_v}{2}$$




$$\sin\gamma = \frac{S_p}{2S_{op}} \Rightarrow S_{op} = \frac{S_p}{2\sin\gamma}$$

$$\cos\gamma = \frac{L_v \cancel{2}}{\cancel{2}(L_v + \Delta L_v)}$$

$$L_v + \Delta L_v = \frac{L_v}{\cos\gamma}$$

$$\Delta L_v = L_v\left(\frac{1}{\cos\gamma} - 1\right)$$

$$\sigma_{op} = E\,\varepsilon_{op}$$

$$\frac{S_{op}}{A} = E\,\frac{\Delta L + \Delta L_v}{L}$$

$$S_{op} = \frac{AE}{L}\left(S_0'\,\frac{L}{AE} + L_v\left(\frac{1}{\cos\gamma} - 1\right)\right)$$

$$S_{op} = S_0' + \frac{L_v}{L}\,\underbrace{AE\left(\frac{1}{\cos\gamma} - 1\right)}_{K}$$

$$\frac{S_p}{2\sin\gamma} = S_0' + K\frac{L_v}{L}$$

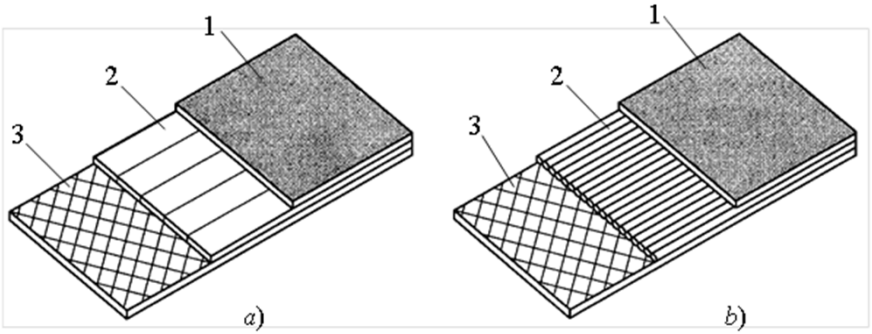
$$S_0' = \frac{S_p}{2\sin\gamma} - K\frac{L_v}{L}$$

$K$ KONSTANTA JERMENA, KI JO DEFINIRA PROIZVAJALEC JERMENA

$\gamma$ TUDI DEFINIRA PROIZVAJALEC JERMENOV

# ZGRADBA JERMENOV

## PLOŠČATI JERMENI



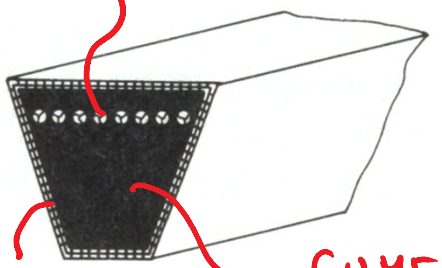

1- krovna plast, 2- vlečna plast, 3- toma plast

TORNA PLAST : ELASTOMER , ZOBOVJU USNJE

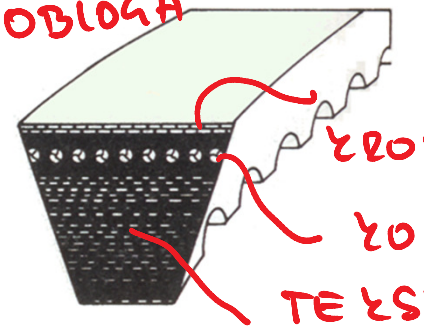
VLEČNA PLAST : POLIAMIDNI TRAK, ZORDNE VRVICE

ZROVNA PLAST : TEKSTILNA TKANINA

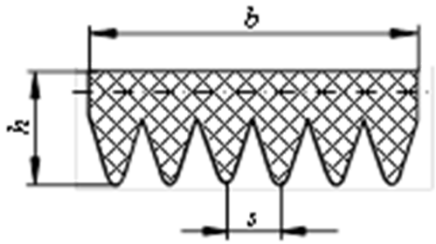
# KLINASTI JERMENI




OPLAŠČENI KLINASTI JERMEN
NORMALNA ALI OZKA IZVEDBA



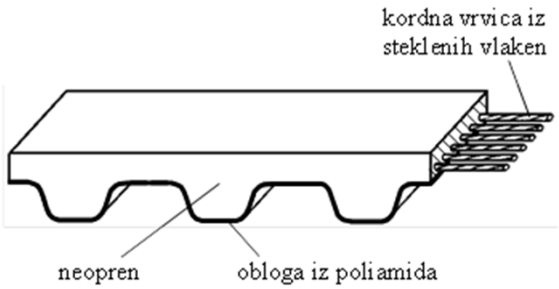

REZANI KLINASTI JERMEN
NORMALNA ALI OZKA IZVEDBA




$h$ višina jermena
$s$ razmak med rebri
$b$ širina jermena
$Z$ število reber

REBRASTI KLINASTI JERMEN

# ZOBATI JERMENI




a)

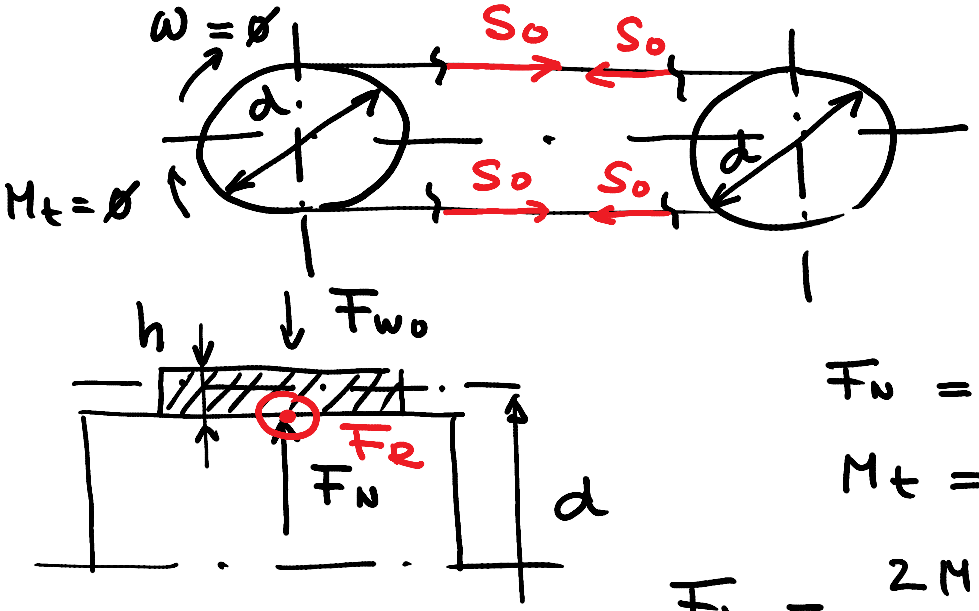
VLEČNA PLAST : KORDNE VRVICE IZ JEKLA, STEKLENIH VLAKEN, KEVLARJA

ZAŠČITNA PLAST : NEOPREN

ZOBJE : NEOPREN

OBLOGA : POLIAMID

# PRIMERJAVA PLOŠČATEGA IN KLINASTEGA JERMENA GLEDE NA SILO NA GREDI $F_{W0}$




$i = 1$

$F_{W0} = 2\,S_0$

$F_N = F_{W0}$

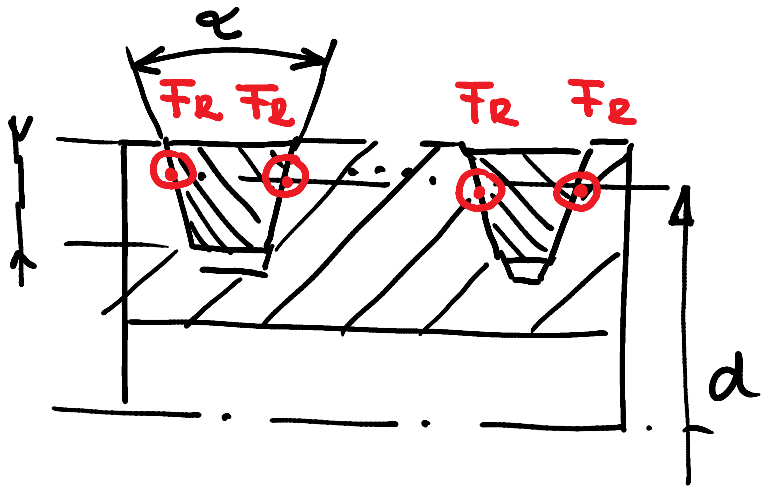
$M_t = \dfrac{F_t \cdot d}{2}$

MOMENT, KI GA ŽELIMO PRENAŠATI PREKO GONILA

$F_t = \dfrac{2M_t}{d}$

$F_t \leq F_R = F_N \mu = F_{W0} \cdot \mu$

$F_{W0} \geq \dfrac{F_t}{\mu}$




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

$$F_t \leq F_R \cdot 2 \cdot i$$

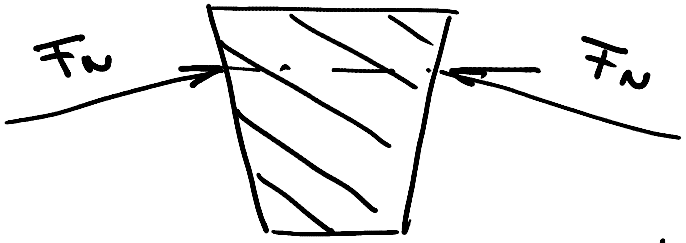
$i$ ŠTEVILO JERMENOV

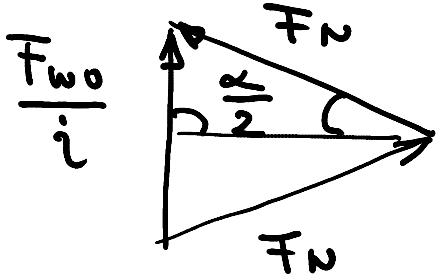
$$F_t \leq F_N \cdot \mu \cdot 2 \cdot i$$

$$\leq \frac{F_{WO}}{2i \sin\frac{\alpha}{2}} \mu \, 2 \cdot i$$

$$F_t \leq \frac{F_{WO}\,\mu}{\sin\frac{\alpha}{2}}$$

$$F_{WO} \geq \frac{F_t}{\mu} \sin\frac{\alpha}{2}$$




$$\sin\frac{\alpha}{2} = \frac{F_{WO}}{2i\,F_N}$$

$$F_N = \frac{F_{WO}}{2i \sin\frac{\alpha}{2}}$$

# VREDNOTENJE JERMENSKIH GONIL

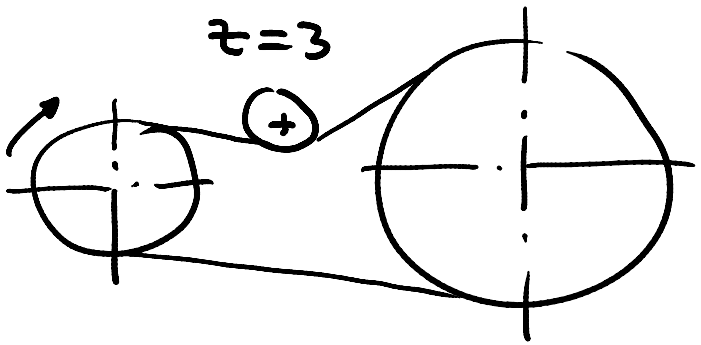
- OBODNA HITROST JERMENA

$v \leq v_{dop}$ PRI VISOKIH $v$ OBSTAJA NEVARNOST TRENUTNEGA LOMA (EKSPLOZIJE) JERMENICE ZARADI CENTRIFUGALNE SILE

- UPOGIBNA FREKVENCA JERMENA

$$f = \frac{v\,z}{L} \leq f_{dop}$$ NEVARNOST UTRUJENOSTNEGA LOMA

$z$: ŠTEVILO JERMENIC



- MAKSIMALNA NAPETOST V JERMENU

$\sigma_{max} \leq \sigma_{dop}$ NEVARNOST TRENUTNEGA LOMA

- ŠIRINA JERMENA OZIROMA ŠTEVILO JERMENOV

$b \geq \frac{P}{P_i}$ [mm] PLOŠČATI IN ZOBATI JERMENI

P: MOČ, ZI JO PRETO GONILA PRENAŠAMO [kW]

$P_i$: IMENSKA MOČ JERMENA [kW/mm]

$i \geq \frac{P}{P_i}$ [-] KLINASTI JERMEN

$P_i$: IMENSKA MOČ JERMENA [kW/JERMEN]

i : ŠTEVILO JERMENOV