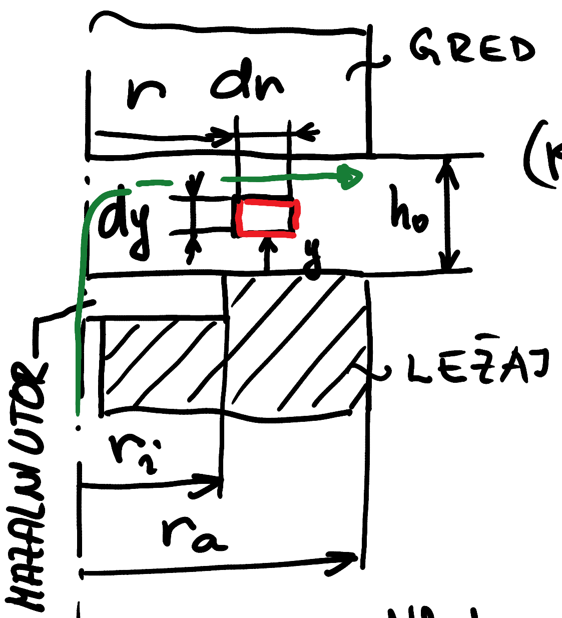
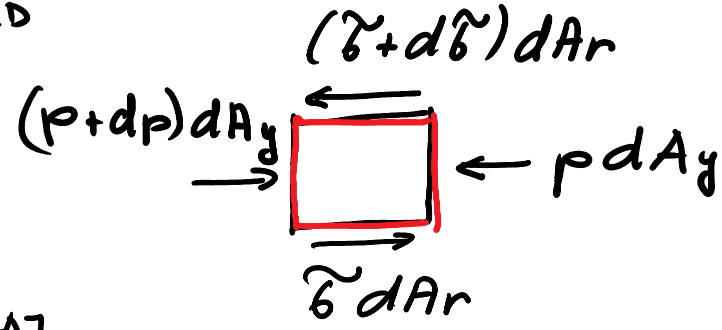
# AKSIALNI DRSNI LEŽAJ

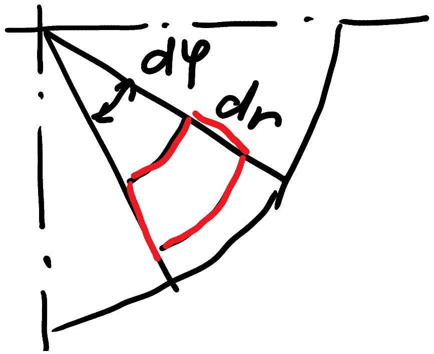
NI ZA IZPIT IZ SE1 !




$$dA_r = r\,d\varphi\,dr$$

$$dA_y = r\,d\varphi\,dy$$



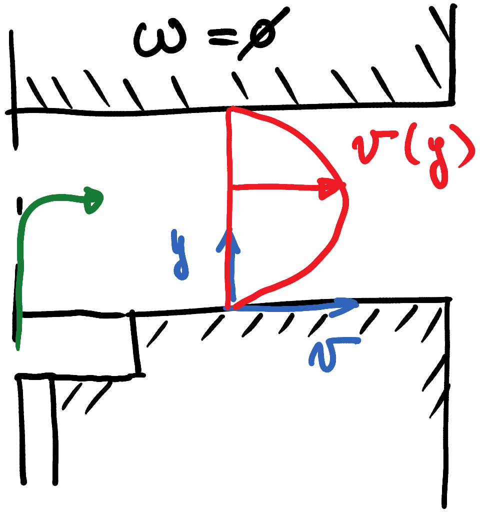

RAVNOTEŽJE SIL

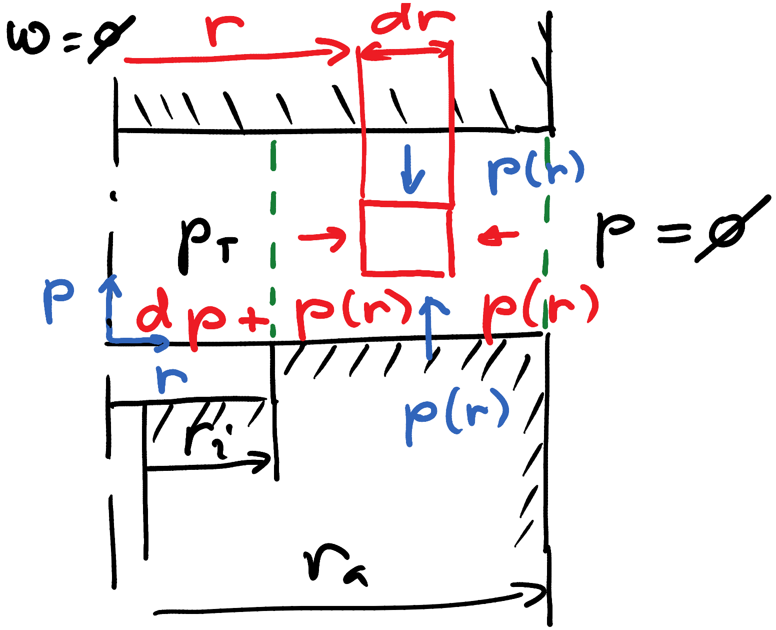
$$0 = (\cancel{p}+dp)dA_y - \cancel{p\,dA_y} + \cancel{\tau\,dA_r} - (\cancel{\tau}+d\tau)dA_r$$

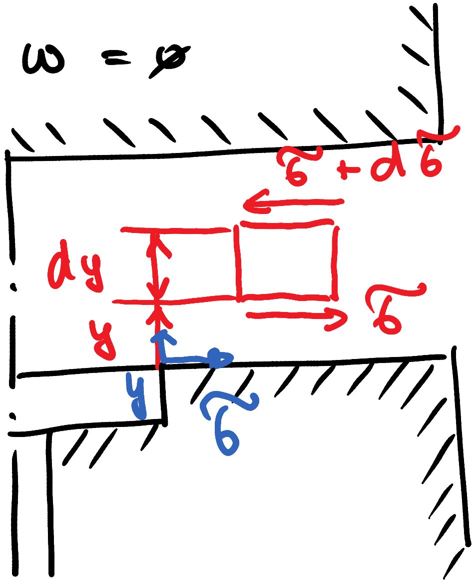
$$dp\,dA_y = d\tau\,dA_r$$

$$dp\,\cancel{r}\,\cancel{d\varphi}\,dy = d\tau\,\cancel{r}\,\cancel{d\varphi}\,dr$$

$$\frac{dp}{dr} = \frac{d\tau}{dy}$$




$\rightarrow v(y)$

$$\tau = \eta \frac{dv}{dy} = \tau(y)$$

KER JE $\tau = \eta \frac{dv}{dy}$ JE $\frac{dp}{dr} = \eta \frac{d^2v}{dy^2}$

R.P. $y = \phi \,;\, v = \phi$ NEDOLOČENO INTEGRIRAMO

$y = h_0 \,;\, v = \phi$

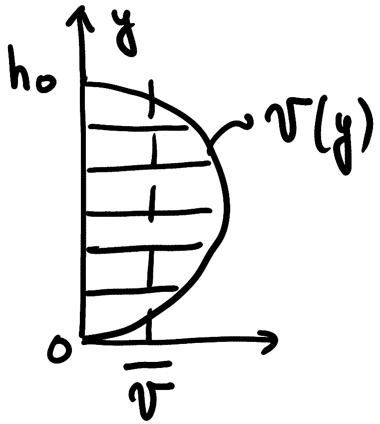
$$\frac{dv}{dy} = \frac{1}{\eta}\frac{dp}{dr}\, y + C_1$$

$$v(y) = \frac{1}{2\eta}\frac{dp}{dr}\, y\,(y - h_0)$$

$$v(y) = \frac{1}{2\eta}\frac{dp}{dr}\, y^2 + C_1 y + C_2$$

$C_2 = \emptyset$

$$\emptyset = \frac{1}{2\eta}\frac{dp}{dr}\, h_0^{\cancel{2}} + C_1 \cancel{h_0} \Rightarrow C_1 = -\frac{1}{2\eta}\frac{dp}{dr}\, h_0$$



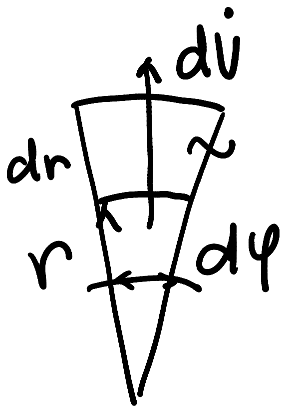

## POVPRECNA HITROST

$$\bar{v} = \frac{1}{h_0}\int_0^{h_0} v(y)\,dy = \frac{1}{2\eta h_0}\frac{dp}{dr}\left[\int_0^{h_0} y^2\,dy - h_0\int_0^{h_0} y\,dy\right]$$

$$= \frac{1}{2\eta h_0}\frac{dp}{dr}\left[\frac{h_0^3}{3}-\frac{h_0^3}{2}\right] = -\frac{h_0^2}{12\eta}\frac{dp}{dr}$$

## VOLUMSKI PRETOK

$$d\dot{V} = \bar{v}\,dA_y$$




$$\int_0^{\dot{V}} d\dot{V} = -\frac{h_0^2}{12\eta}\frac{dp}{dr}\, r\int_0^{2\pi} d\varphi\int_0^{h_0} dy$$

$$\dot{V} = -\frac{h_0^2}{12\eta}\frac{dp}{dr}\, r\, 2\pi\, h_0 = -\frac{h_0^3 r \pi}{6\eta}\frac{dp}{dr}$$

KER JE $\dot{V}$ ZNAN IN GA DOLOČA ČRPALKA LAHKO IZRAČUNAMO TLAK $p(r)$

R.P. $r = r_a$ ; $p(r) = \phi$

$$\int dp = -\frac{\dot{V} 6 \eta}{h_0^3 \pi} \int \frac{dr}{r}$$

$$p(r) = -\frac{\dot{V} 6 \eta}{h_0^3 \pi} \ln r + C_1$$

$$p(r_a) = \phi = -\frac{\dot{V} 6 \eta}{h_0^3 \pi} \ln r_a + C_1$$

$$C_1 = \frac{\dot{V} 6 \eta}{h_0^3 \pi} \ln r_a$$

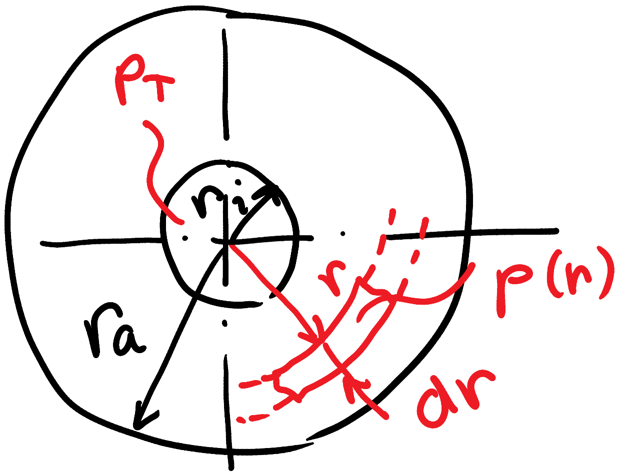
$$p(r) = \frac{6 \cdot \eta \dot{V}}{h_0^3 \pi} \ln \frac{r_a}{r}$$

OB PREDPOSTAVKI, DA POZNAMO TLAK V MAZALNEM UTORU $p_T$ LAHKO IZRAČUNAMO POTREBNI VOLUMSKI PRETOK $\dot{V}$

$$p(r_i) = p_T = \frac{6\eta \dot{V}}{h_0^3 \pi} \ln \frac{r_a}{r_i}$$

$$\dot{V} = \frac{p_T h_0^3 \pi}{6 \eta \ln \frac{r_a}{r_i}}$$

SILA, KI JO LAHKO PREVZAME LEŽAJ




$$\int_0^F dF = 2\pi p_T \int_0^{r_i} r\,dr + 2\pi \int_{r_i}^{r_a} p(r)\, r\,dr$$

$$F = 2\pi \int_0^{r_i} p_T \, r \, dr + 2\pi \int_{r_i}^{r_a} p(r) \, r \, dr = \frac{\pi}{2} \frac{p_T (r_a^2 - r_i^2)}{\ln \frac{r_a}{r_i}}$$

$$= \frac{2\pi \, p_T \, \cancel{r_i^2}}{\cancel{2}} + \frac{2\pi \, p_T}{\ln \frac{r_a}{r_i}} \Big[ \underbrace{\int_{r_i}^{r_a} \ln r_a \, r \, dr}_{I_1} - \underbrace{\int_{r_i}^{r_a} \overset{v'}{r} \, \underset{u}{\ln r} \, dr}_{I_2} \Big]$$

$$I_1 = \ln r_a \, \frac{\cancel{r_a^2 - r_i^2}}{2}$$

$$u = \ln r \qquad du = \frac{1}{r}$$

$$v' = r \qquad v = \frac{r^2}{2}$$

$$I_2 = v \cdot u - \int v u' \, dr = \frac{r^2}{2} \ln r - \int \frac{r}{2} \, dr$$

$$= \frac{r^2}{2} \ln r - \frac{r^2}{4} \Big|_{r_i}^{r_a} = \cancel{\frac{r_a^2}{2} \ln r_a} - \cancel{\frac{r_i^2}{2} \ln r_i} - \frac{r_a^2 - r_i^2}{4}$$

V ENAČBO ZA $p(r)$ NAJPREJ VSTAVIMO KONČNO ENAČBO ZA $\dot{V}$

$$p(r) = \frac{6\eta\dot{V}}{h_0^3\pi}\ln\frac{r_a}{r}$$

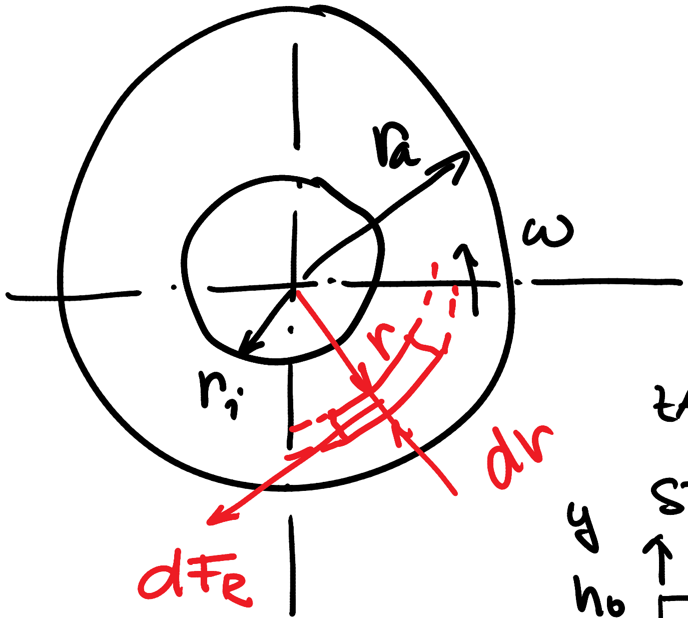
$$\dot{V} = \frac{p_T h_0^3\pi}{6\eta\ln\frac{r_a}{r_i}}$$

$$p(r) = \frac{\cancel{6\eta}}{\cancel{h_0^3\pi}}\frac{p_T\cancel{h_0^3\pi}}{\cancel{6\eta}\ln\frac{r_a}{r_i}}\ln\frac{r_a}{r} = \frac{p_T}{\ln\frac{r_a}{r_i}}\ln\frac{r_a}{r}$$

PO INTEGRACIJI PO DELIH DOBIMO

$$F = \frac{p_T\pi}{2}\frac{r_a^2 - r_i^2}{\ln\frac{r_a}{r_i}}$$

## MOMENT TRENJA

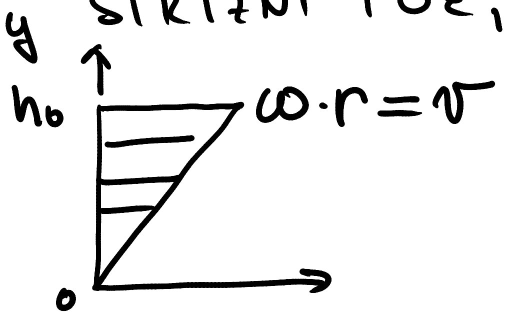



SILA TRENJA

$$\tau = \frac{dF_R}{2\pi r\,dr} = \eta \frac{dv}{dy}$$

$$dF_R = 2\pi r\,dr\,\eta \frac{dv}{dy}$$

ZARADI VRTENJA GREDI SE USTVARJA STRIŽNI TOK, ZATO JE $\frac{dv}{dy} = \text{const}$




$$\frac{dv}{dy} = \frac{\omega r}{h_0} = a$$

$y = h_0$, $v = \omega r$

$y = 0$, $v = 0$

$$v = \omega \cdot r$$

$$v(y) = a y + \cancel{b}^{\,0}$$

$$\omega r = a h_0$$

$$dF_R = 2\pi r^2\,dr\,\eta \frac{\omega}{h_0}$$

$$dM_R = dF_R\, r$$

$$\int_0^{M_R} dM_R = \int r\, dF_R = \frac{2\pi \eta \omega}{h_0} \int_{r_i}^{r_a} r^3\, dr = \frac{\pi \eta \omega}{2 h_0}\left(r_a^4 - r_i^4\right)$$

$$= M_R$$

MOČ TRENJA

$$P_R = M_R\, \omega = \frac{\pi \eta \omega^2 \left(r_a^4 - r_i^4\right)}{2 h_0}$$

MOČ ČRPALKE

$$P_p = \dot{V}\, p_z \frac{1}{\eta_p}$$

$\eta_p$ – IZKORISTEK ČRPALKE

$p_z$ – TLAK ČRPALKE

$$p_z \cong p_T$$

$$P = F \cdot v = p\, A \cdot v = p\, \dot{V} = \left[\frac{N}{m^2} \cdot \frac{m^3}{s}\right]$$

BILANCA MOCI IN PRIRASTEK TEMPERATURE

$$P_p + P_e = \frac{dQ}{dt} = \rho\, c\, \Delta T\, \dot{V}$$

TOPLOTA $Q = m \cdot c\, \Delta T = \rho\, V\, c\, \Delta T$

$$\Delta T = \frac{P_p + P_e}{\rho\, c\, \dot{V}}$$