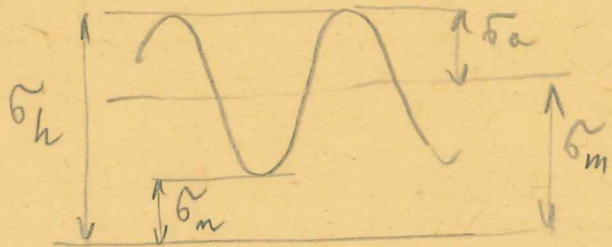


4.331

$$\begin{aligned} \bar{\sigma}_h &= 60 \text{ MPa} & \bar{\sigma}_m &= ? \\ \bar{\sigma}_n &= 26 \text{ MPa} & \bar{\sigma}_a &= ? \end{aligned}$$

druh kmitání



Teprve v tahu

$$\begin{aligned} \bar{\sigma}_m &= \frac{\bar{\sigma}_h + \bar{\sigma}_n}{2} = 43 \text{ MPa} \\ \bar{\sigma}_a &= \bar{\sigma}_h - \bar{\sigma}_m = 17 \text{ MPa} \end{aligned}$$

4.332

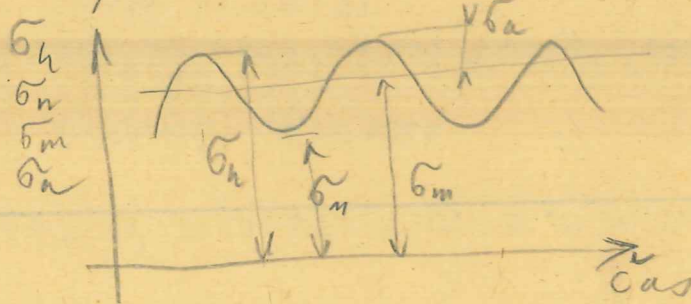
Tyč $\phi d = 20 \text{ mm}$ namáčen tahem

$$F_{\max} = 31\,400 \text{ N}, \quad F_{\min} = 10\,000 \text{ N}$$

$$\bar{\sigma}_h = \frac{F_{\max}}{\frac{\pi d^2}{4}} = \frac{4 F_{\max}}{\pi \cdot 20^2} = \frac{4 \cdot 31\,400}{\pi \cdot 20^2} = 99,94 \text{ MPa}$$

$$\bar{\sigma}_n = \frac{4 \cdot F_{\min}}{\pi \cdot d^2} = \frac{4 \cdot 10\,000}{\pi \cdot 20^2} = 31,83 \text{ MPa}$$

Teprve v tahu



$$\begin{aligned} \bar{\sigma}_m &= \frac{\bar{\sigma}_h + \bar{\sigma}_n}{2} = \frac{99,94 + 31,83}{2} \\ &= 65,88 \text{ MPa} \end{aligned}$$

$$\bar{\sigma}_a = \bar{\sigma}_h - \bar{\sigma}_m = 34,06 \text{ MPa}$$

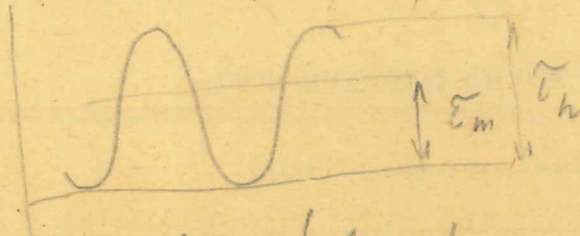
4.333

Hřídel $\phi d = 20 \text{ mm}$

Střední hodnota $M_k = 120 \text{ Nm}$

$$\bar{\tau}_m = 0; \quad \bar{\tau}_m = ?$$

$$\bar{\tau}_h = \frac{M_k}{W_k} = \frac{16 \cdot 120\,000}{\pi d^3}$$



$$= \frac{16 \cdot 120\,000}{\pi \cdot 20^3} = 76,39 \text{ MPa}$$

Míjivý krut

$$\bar{\tau}_a = \frac{\bar{\tau}_h}{2} = 38,19 \text{ MPa}$$

$$\bar{\tau}_m = \bar{\tau}_a = 38,19 \text{ MPa}$$

4.334

$\bar{\sigma}_h = ?$, $\bar{\sigma}_m = ?$

(2)

$\bar{\sigma}_m = 20 \text{ MPa}$

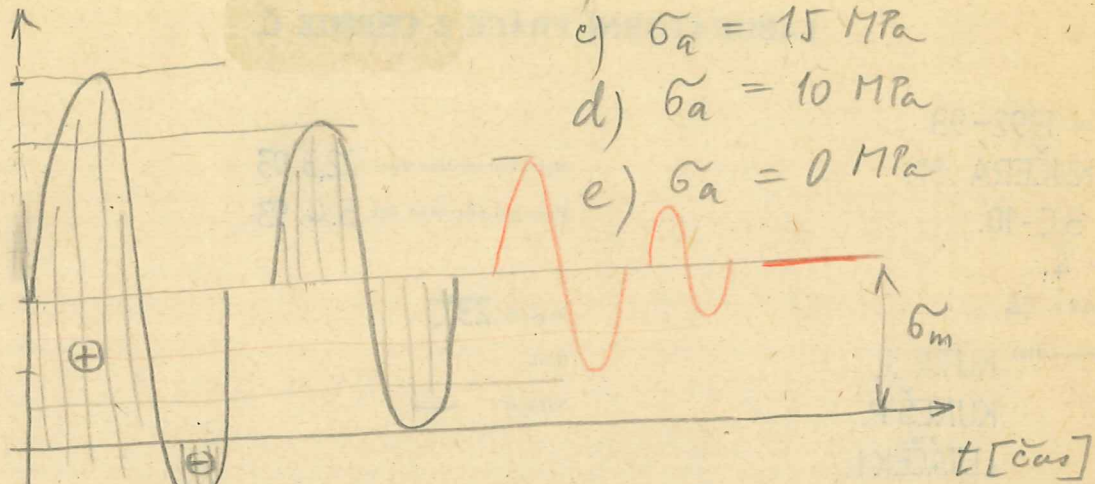
a) $\bar{\sigma}_a = 30 \text{ MPa}$

b) $\bar{\sigma}_a = 20 \text{ MPa}$

c) $\bar{\sigma}_a = 15 \text{ MPa}$

d) $\bar{\sigma}_a = 10 \text{ MPa}$

e) $\bar{\sigma}_a = 0 \text{ MPa}$



a) $\bar{\sigma}_h = \bar{\sigma}_m + \bar{\sigma}_a = 50 \text{ MPa}$, $\bar{\sigma}_n = \bar{\sigma}_m - \bar{\sigma}_a = -10 \text{ MPa}$
 b) $\bar{\sigma}_h = 40$, $\bar{\sigma}_n = 0$
 c) $\bar{\sigma}_h = 35$, $\bar{\sigma}_n = 5$
 d) $\bar{\sigma}_h = 10$, $\bar{\sigma}_n = 10$
 e) $\bar{\sigma}_h = \bar{\sigma}_n = \bar{\sigma}_m$ - statické

Stridavý, rezonančný, *mújivý* / *soh*, *polozijie* / *v tohu*, statické

4.335

$\bar{\sigma}_{Pt} = 400 \text{ MPa}$ $d_0 = 10 \text{ mm}$

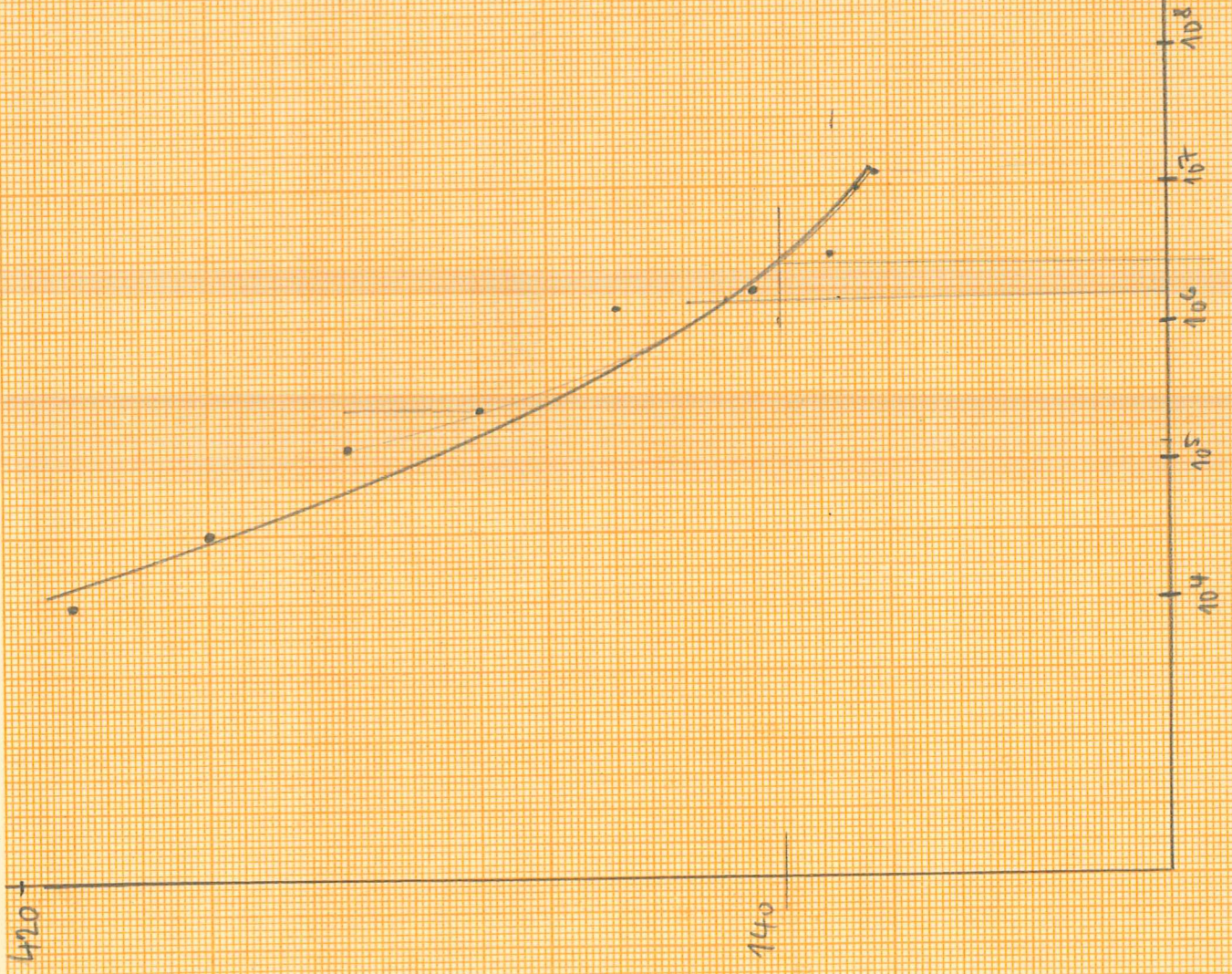
4.336

1. $\bar{\sigma}_{h1} = 420 \text{ MPa}$ - $N_1 = 2 \text{ kmij}$ - *procola*

2. $\bar{\sigma}_{h2} = 400 \text{ MPa}$ - $N_2 = 10^4$ - *---*

3. $\bar{\sigma}_{h3} = 350 \text{ MPa}$ - $N_3 = 5 \cdot 10^4$ - *---*

↓ viz usobnice p'v'ho



$\sigma_{LC} = 0 \pm 110 \text{ MPa} \quad (200 \text{ Hz})$

$N = 4 \cdot 10^6 \text{ cycles} \quad \sigma_L = 140 \text{ MPa}$

$N = 2 \cdot 10^6 \text{ cycles} \quad \sigma_L = 162,5 \text{ MPa}$

4.338

$$\sigma = 60 \text{ MPa}$$

$$\sigma_{th}(hnc) = 60 \text{ MPa}$$

4.339

$$\sigma_c = 0,35 \sigma_{pt} \quad \text{tab}$$

$$\underline{147 + \sigma_m}$$

#

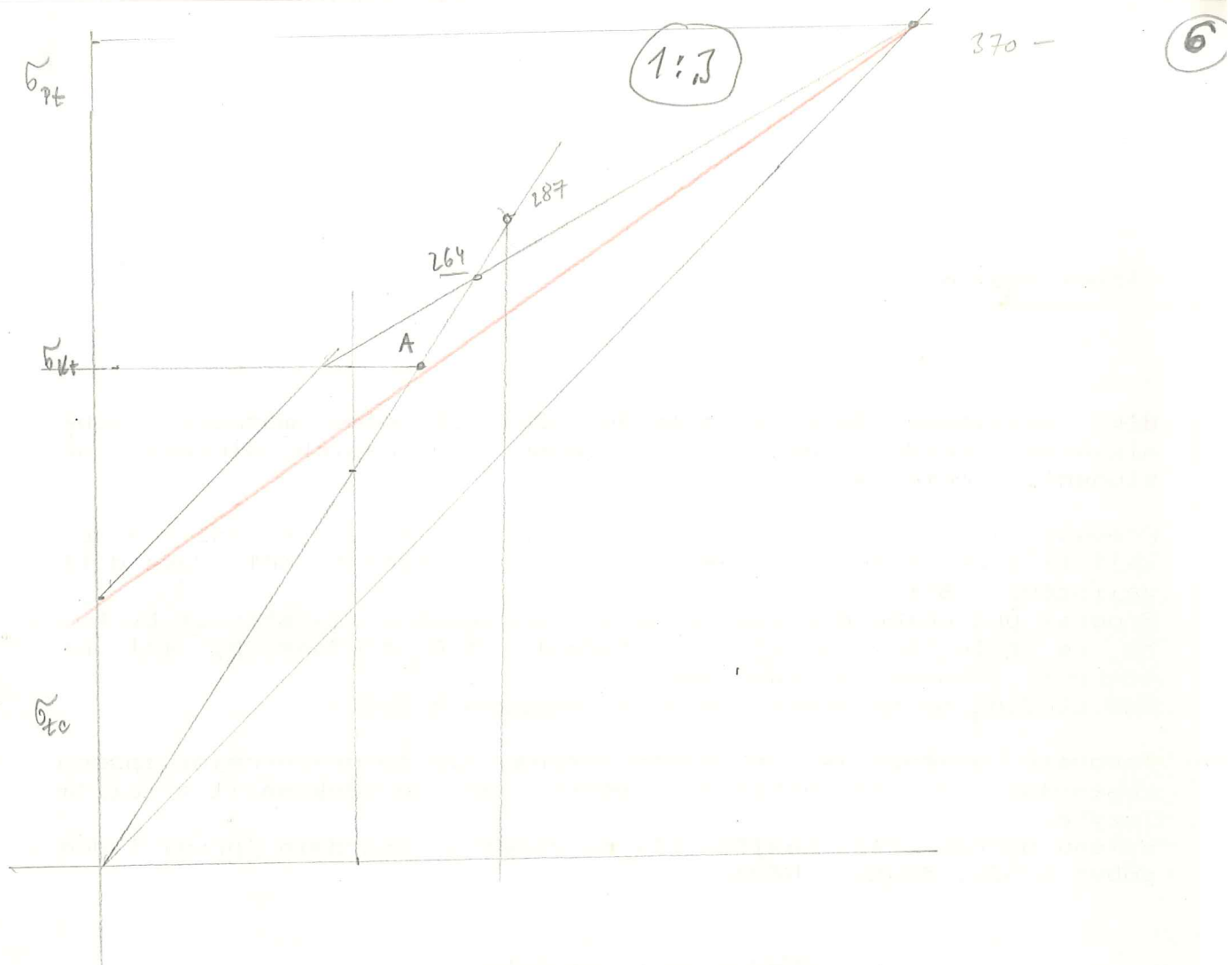
4.346 mat. 11373 - $\phi d = 10 \text{ mm}$

$$\sigma_{th}(hc)_{ef} = 120 \text{ MPa} \quad \text{z diagramu 4.179}$$

zjisti te mernu napeti mifivets ejllu 4.180

$$\begin{aligned} \sigma_{kk} &= 0,6 \sigma_{kt} = 0,6 \cdot 0,6 \cdot \sigma_{pt} = \\ &= 0,36 \cdot 370 = 133,2 \text{ MPa} \end{aligned}$$

$$\sigma_{th}(hc) = 133,2 \text{ MPa}$$



4.350

$d = 45 \text{ mm}$ — $\alpha = 11,373$

terut součinné střídaní

$\bar{\sigma}_{\text{cef}} = ?$ při konstantní střední úroveň

$\bar{\sigma}_{\text{kc}} = 0,25 \sigma_{\text{PE}} = 0,25 \cdot 370 = \underline{92,5 \text{ MPa}}$

71,6

$\bar{\sigma}_{\text{cef}} = \bar{\sigma}_{\text{kc}} \frac{\epsilon_m \epsilon_p}{\beta} = 92,5 \cdot 0,77 \cdot 0,65 = \underline{46 \text{ MPa}} \text{ (71,6)}$

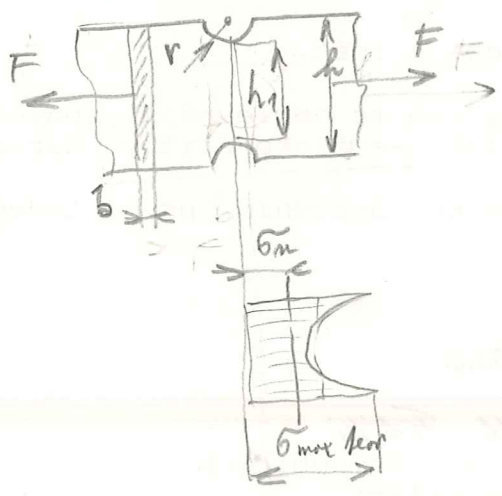
$\beta = 1$

$\epsilon_m = 0,91$?

$\epsilon_p = 0,65$

ZNOVU!

4.351) *ve škole*



$b = 6 \text{ mm}$ $F = 9600 \text{ N}$

$h = 24 \text{ mm}$

$r = 4 \text{ mm}$

a) $\bar{\sigma}_m = ?$

b) $\bar{\sigma}_{\text{max. teor.}} = ?$

$\bar{\sigma}_m = \frac{F}{b(h-2r)} = \frac{9600}{6(24-8)} = 100 \text{ MPa}$

$\bar{\sigma}_{\text{max. teor.}} = \alpha \bar{\sigma}_m = \underline{190 \text{ MPa}}$

$\frac{h}{h_1} = \frac{24}{16} = 1,5$

z diagr. 4.185 $\alpha = 1,9$

$\frac{r}{h_1} = \frac{4}{16} = 0,25$

4.352

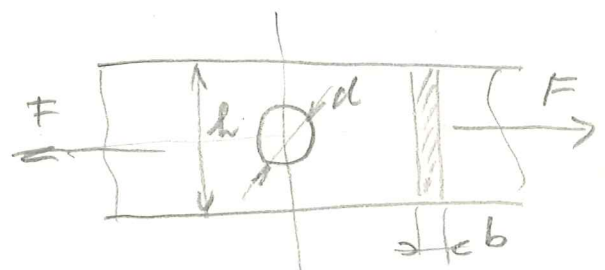
zadání 4.351

$d = 2r = 8 \text{ mm}$

$b = 6 \text{ mm}$

$F = 9600 \text{ N}$

$h = 24 \text{ mm}$



$\bar{\sigma}_m = 100 \text{ MPa}$

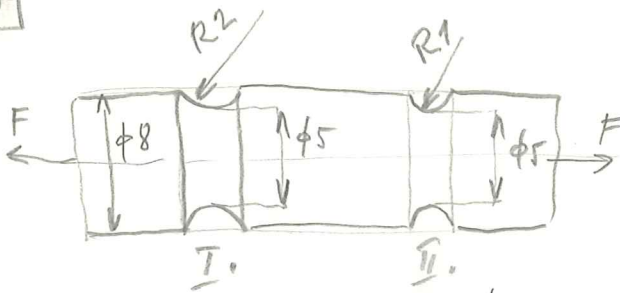
$\bar{\sigma}_{\text{max. teor.}} = \alpha \bar{\sigma}_m = \underline{235 \text{ MPa}}$

z 4.187

$\alpha = 2,35$

$\frac{d}{h} = \frac{8}{24} = 0,33$

4.353



$$\alpha_{II} < 1,6$$

$$\alpha_{II} = 1,75$$

diagram 4.189

$$\textcircled{2} \frac{R}{d} = \frac{2}{5} = 0,4$$

$$\frac{D}{d} = \frac{8}{5} = 1,6 / \alpha < 1,6$$

$$\textcircled{1} \frac{R}{d} = \frac{1}{5} = 0,2$$

$$\alpha = 1,8$$

$\alpha_{II} > \alpha_I$ je závrisk II nebezpečnější

4.354

základní 353 ale hřídel je ořeván.

diagram 4.192
4.193

$$\text{I} \quad \frac{r}{D-d} = \frac{2}{8-5} = 0,66$$

$$\frac{R}{d} = \frac{2}{5} = 0,4 \quad \alpha_{I0} = 1,64$$

$$\text{II} \quad \frac{r}{D-d} = \frac{1}{8-5} = 0,33$$

$$\frac{R}{d} = \frac{1}{5} = 0,25 \quad \alpha_{II0} = 1,52$$

MIMO DIAGRAM

STORNE

4.355

$$\eta = ? \quad \beta = ?$$

$$r = 4 \text{ mm}$$

$$b = 6 \text{ mm}$$

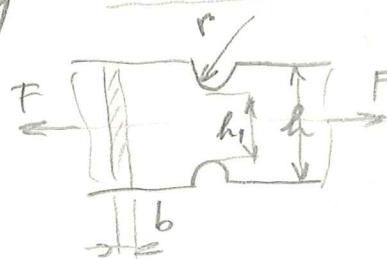
$$h = 24 \text{ mm}$$

$$\eta = 0,7$$

$$\beta = 1,63$$

11 500 základní 4.351

diagram 4.184
4.194



$$\alpha = 1,9$$

$$\eta = 0,62 \text{ z diagramu}$$

4.194

$$\beta = 1 + (\alpha - 1) \eta$$

$$\alpha = 1,9$$

$$= 1 + (1,9 - 1) 0,62 = \underline{\underline{1,558}}$$

4.356

pro litiinu $\eta = 0$ pro svou strukturu

$$\underline{\underline{\beta = 1}}$$

4.357

 $\bar{\sigma}_{skt}$

11423

(9)

a) Hålls + prilladen 4.357 ($\bar{\sigma}_m = 100 \text{ MPa}$) $\alpha = 1,9$

$$\bar{\sigma}_{skt} = \beta \bar{\sigma}_m = 1,495 \cdot 100 = \underline{\underline{149,5 \text{ MPa}}}$$

$$\beta = 1 + (\alpha - 1) \gamma = 1 + (1,9 - 1) 0,55 = 1,495$$

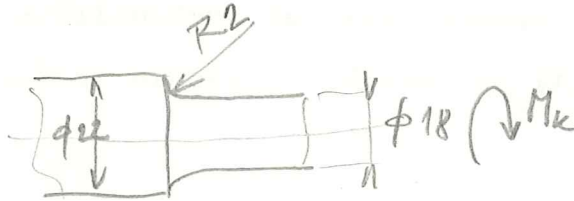
b) 4.352

$\bar{\sigma}_m = 100 \text{ MPa}$

$\alpha = 2,35, \gamma = 0,58$

$\beta = 1 + (\alpha - 1) \gamma = 1 + 1,35 \cdot 0,58 = 1,783$

$\bar{\sigma}_{skt} = \bar{\sigma}_m \beta = 100 \cdot 1,783 = \underline{\underline{178,3 \text{ MPa}}}$

4.358 *ve shok*

$\tau_{cef} = ?$

11600

brons

$M_{k \max} = 60 \text{ Nm}$

Sovetskoye Standard

$\tau_{ke} = 0,25 \sigma_{pe} = 0,25 \cdot 600 = 150 \text{ MPa}$

$\frac{R}{d} = \frac{2}{18} = 0,1$

$$\tau_{ke \text{ ef}} = \tau_{ke} \frac{\epsilon_m \cdot \epsilon_p}{\beta} = 150 \frac{0,9 \cdot 0,95}{1,5} = \underline{\underline{85,5 \text{ MPa}}}$$

$\beta = 1,5$
ST sh. 70

$\epsilon_p = 0,95$

$\epsilon_m = 0,9$

$\tau_{kh} = \frac{M_k}{W_k} = \frac{60000}{1145} = 52,4 \text{ MPa}$

$W_k = \frac{\pi}{16} d^3 = \frac{\pi}{16} 18^3 = 1145 \text{ mm}^3$

$\tau_{kh} < \tau_{ke \text{ ef}}$ *uzlovuje*

4.359

$$k_d = \frac{\sigma_{keof}}{\sigma_{zh}} = \frac{85,5}{52,4} = 1,63 \quad \text{z příkl. 4.358}$$

(10)

$$\sigma_{kco} = \frac{\sigma_{keof}}{k_d} = \frac{85,5}{1,5} = 57 \text{ MPa}$$

4.360

příkl. 4.358 prole c_{II} c_{III} pro $k=2$
a porovnej z 4.359



$$c_{II} = 0,75$$

$$c_{III} = 0,6$$

$$\sigma_{DK II} = \frac{\sigma_k}{k} \cdot c_{II} = \frac{0,5 \cdot 0,5 \cdot 600}{2} \cdot 0,75 = \underline{\underline{89 \text{ MPa}}}$$

$$\sigma_{DK III} = \frac{0,36 \cdot 600}{2} \cdot 0,6 = \underline{\underline{64,8 \text{ MPa}}}$$

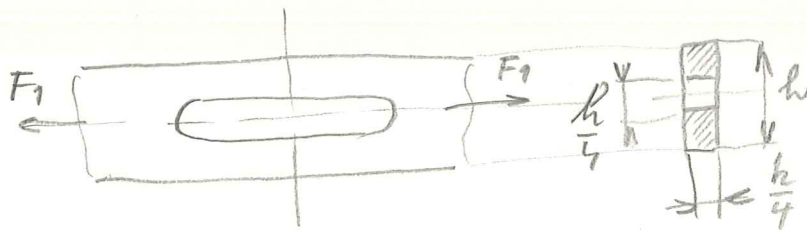
$$\sigma_{keof} = \underline{\underline{85,5 \text{ MPa}}}$$

$$\underline{\underline{\sigma_{DK III} < \sigma_{keof}}}$$

4.361

$$F_{max} = 65000 \text{ N}$$

$$F_{min} = 0 \quad 11373$$



Uvažováno za teplotu

$b : h = 1 : 6$
plošný průřez

Míjivé zatížení

$$k_d = 1,2$$

$$\sigma_{zh}(hc) = 0,61 \sigma_{pt} = 0,61 \cdot 370 = \underline{\underline{225,1 \text{ MPa}}}$$

$$k_d = \frac{\sigma_{zh}(hc)}{\sigma_{zh}(hc)_{prov.}} \quad \sigma_{zh}(hc)_{prov.} = \frac{\sigma_{zh}(hc)}{k_d} = \frac{225}{1,2} = \underline{\underline{187,5 \text{ MPa}}}$$

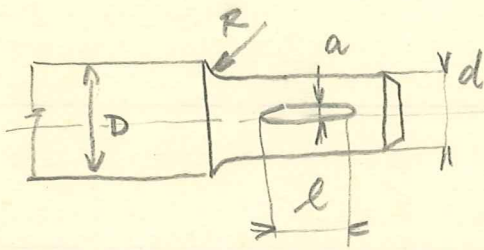
2

4. 362

skrytý příklad jako u učebnice

11

4. 363



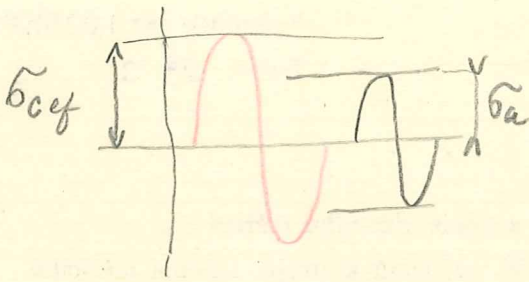
$$F_{\text{ctm}} = 32800 \text{ N} \quad \text{---} \quad 11423$$

$$a = 14 \text{ mm} \quad R$$

$$l = 70 \text{ mm}$$

$$D:d = 1,2$$

$$k_d = 1,2$$

povrch
brnění

$$\bar{\sigma}_{\text{cef}} = \bar{\sigma}_c \frac{E_m \cdot E_d}{\beta}$$

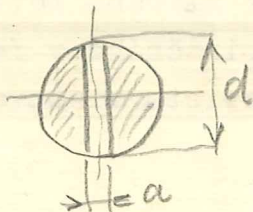
$$\bar{\sigma}_c = 0,32 \cdot \bar{\sigma}_{Pt} = 0,32 \cdot 420 = \underline{\underline{134,4 \text{ MPa}}}$$

$$k_d = \frac{\bar{\sigma}_{\text{cef}}}{\bar{\sigma}_a}$$

$$k = 2,8$$

$$\bar{\sigma}_{Dt_{III}} = c_{III} \frac{0,6 \bar{\sigma}_{Pt}}{k} = 0,65 \frac{0,6 \cdot 420}{2,8} = 58,5 \text{ MPa}$$

$$\bar{\sigma}_{Dt_{III}} = \frac{F}{S} \Rightarrow S = \frac{F}{\bar{\sigma}_{Dt}} = \frac{32800}{58,5} = \underline{\underline{560,68 \text{ mm}^2}}$$



$$S = \frac{\pi d^2}{4} - da \quad \text{krad. rovnice}$$

$$\left(\frac{\pi}{4}\right) d^2 - ad - S = 0$$

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$d_{1,2} = \frac{a \pm \sqrt{a^2 + 4 \frac{\pi}{4} S}}{2 \frac{\pi}{4}} = \frac{14 \pm \sqrt{14^2 + \pi \cdot 560,7}}{\frac{\pi}{2}} = \frac{14 \pm 44,2}{\frac{\pi}{2}}$$

$$= \underline{\underline{37 \text{ mm}}}$$

$$d = 37 \text{ mm}$$

$$D = 1,2 \cdot 37 = 44,4 \doteq \underline{\underline{45 \text{ mm}}}$$

$$R = \frac{D-d}{2} = \frac{45-37}{2} = \underline{\underline{4}}$$

$$\sigma_{cef} = \sigma_c \frac{\epsilon_m \cdot \epsilon_p}{\beta} = 134,4 \frac{1,095}{1,38} = \underline{\underline{78,5 \text{ MPa}}} \quad \left. \begin{array}{l} \epsilon_p = 0,95 \\ \eta = 0,54 \\ \alpha = 2,7 \end{array} \right\} \epsilon_m = 1 \quad (12)$$

$$l_{ed} = \frac{\sigma_{cef}}{\sigma_a} = \frac{92,5}{30,5} = \underline{\underline{3,03}}$$

$$\sigma_a' = \frac{F}{S} = \frac{32800}{\frac{\pi d^2}{4}} = \frac{4 \cdot 32800}{\pi \cdot 37^2} = 30,5$$

$$\frac{R}{d} = \frac{4}{37} = 0,11$$

$$\beta = 1 + (\alpha - 1) \eta = 1,02$$

Pro dráček:

$$\sigma_{cef} = \sigma_c \frac{\epsilon_m \cdot \epsilon_p'}{\beta'} = 134,4 \frac{0,95}{1,7} = \underline{\underline{75,1}}$$

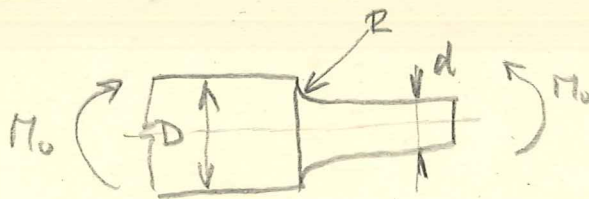
$$l_{ed} = \frac{\sigma_{cef}}{\sigma_a} = \frac{75,1}{58,5} = \underline{\underline{1,28}}$$

$$\sigma_a = 58,5 \text{ MPa} \checkmark$$

$\epsilon_m = 1$
 $\epsilon_p = 0,95$
 $\alpha = 2,3$ ST. str. 69
 $\beta = 1 + (2,3 - 1) \cdot 0,54 = 1,7$

vyboruje

4.364 | Hřídel z 17370 - hromadný
 Zmítací oblož



$$M_{0 \max} = 920 \text{ Nm}$$

$$M_{0 \min} = -200 \text{ Nm}$$

$$l_{ed} = ?$$

$$D = 62 \text{ mm}$$

$$d = 50 \text{ mm}$$

$$r = 8 \text{ mm}$$

$$W_0 = \frac{\pi}{32} d^3 = \frac{\pi}{32} \cdot 50^3 = 12271,8 \text{ mm}^3$$

$$\sigma_h = \frac{M_{0 \max}}{W_0} = \frac{920000}{12271,8} = 74,96 \text{ MPa} = \underline{\underline{75 \text{ MPa}}}$$

$$\sigma_n = \frac{M_{0 \min}}{W_0} = \frac{-200000}{12271,8} = \underline{\underline{-16,3 \text{ MPa}}}$$

$$\sigma_m = \frac{\sigma_h + \sigma_n}{2} = \frac{75 - 16,3}{2} = \underline{\underline{29,35 \text{ MPa}}}$$

$$A_{gd} = \frac{\sigma_R}{\sigma_m} = \frac{75}{29,35} = 2,55 \quad \boxed{\alpha = 68,6^\circ}$$

Pro Smithov diagram

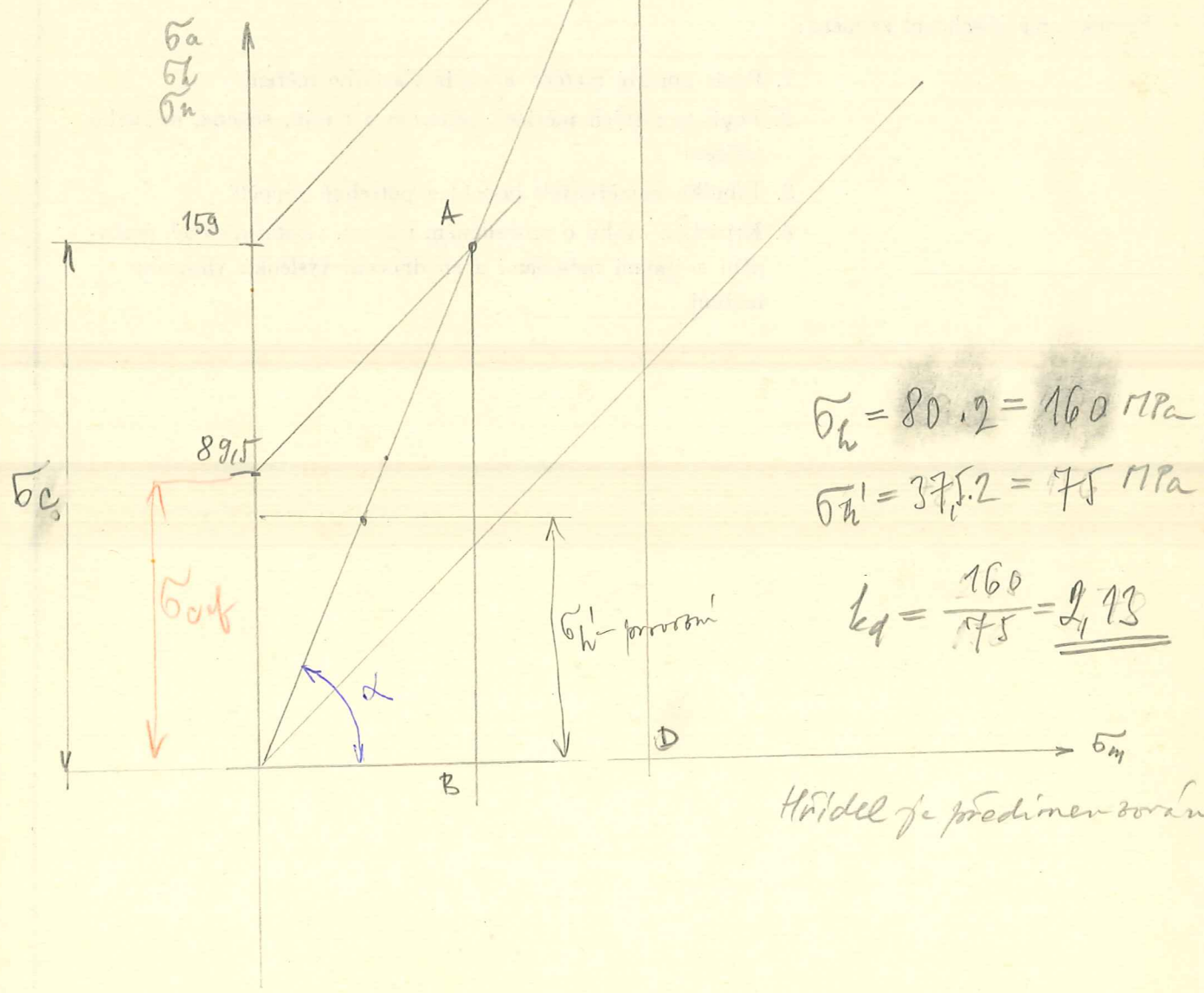
$$\begin{aligned} \bar{\sigma}_{Pt} &= \underline{370 \text{ MPa}} \\ \bar{\sigma}_{Kv} &= 0,7 \cdot 370 = \underline{259 \text{ MPa}} \\ \bar{\sigma}_c &= 0,43 \bar{\sigma}_{Pt} = 0,43 \cdot 370 = \underline{159 \text{ MPa}} \end{aligned}$$

sondierstele

$$\begin{aligned} \beta &= 1,14 \\ \epsilon_m &= 0,83 \\ \epsilon_p &= 0,95 \end{aligned}$$

$$\frac{R}{d} = \frac{8}{50} = 0,16 \text{ ST 8h.70}$$

$$\bar{\sigma}_{\text{eff}} = \bar{\sigma}_c \frac{\epsilon_m \cdot \epsilon_p}{\beta} = 159 \frac{0,83 \cdot 0,95}{1,14} = \underline{89,55 \text{ MPa}}$$



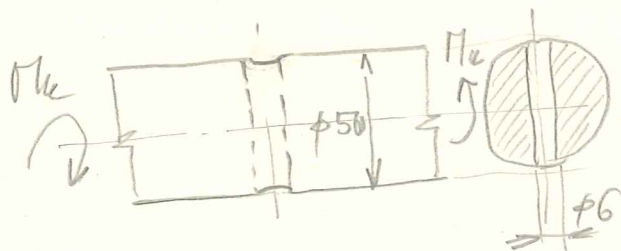
Háidél je predimenzovan

4.365

Lestný hřídel s nasazenou šroubem

14

11370



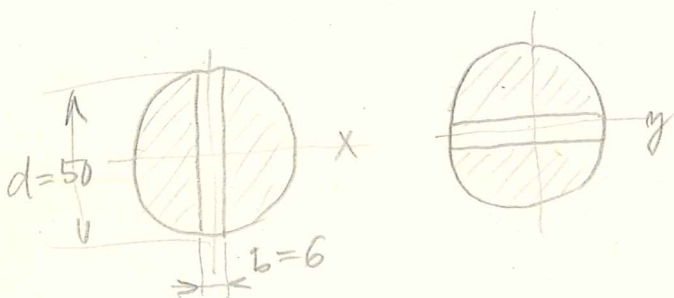
$$M_{km} = 500 \text{ Nm} - \text{střední hodnota}$$

$$M_{ka} = \pm 600 \text{ Nm} - \text{amplituda}$$

$$\text{obr. } 4.200 - \beta$$

$$\underline{\underline{kd = ?}}$$

$$W_k = ?$$



$$J_x = \frac{\pi}{64} d^4 - \frac{d^3 b}{12} = \frac{\pi \cdot 50^4}{64} - \frac{50^3 \cdot 6}{12} = 306796 - 62500 = \underline{\underline{244296 \text{ mm}^4}}$$

$$J_y = \frac{\pi d^4}{64} - \frac{d b^3}{12} = 306796 - 900 = \underline{\underline{305896 \text{ mm}^4}}$$

$$J_p = J_x + J_y = 244296 + 305896 = \underline{\underline{550192 \text{ mm}^4}}$$

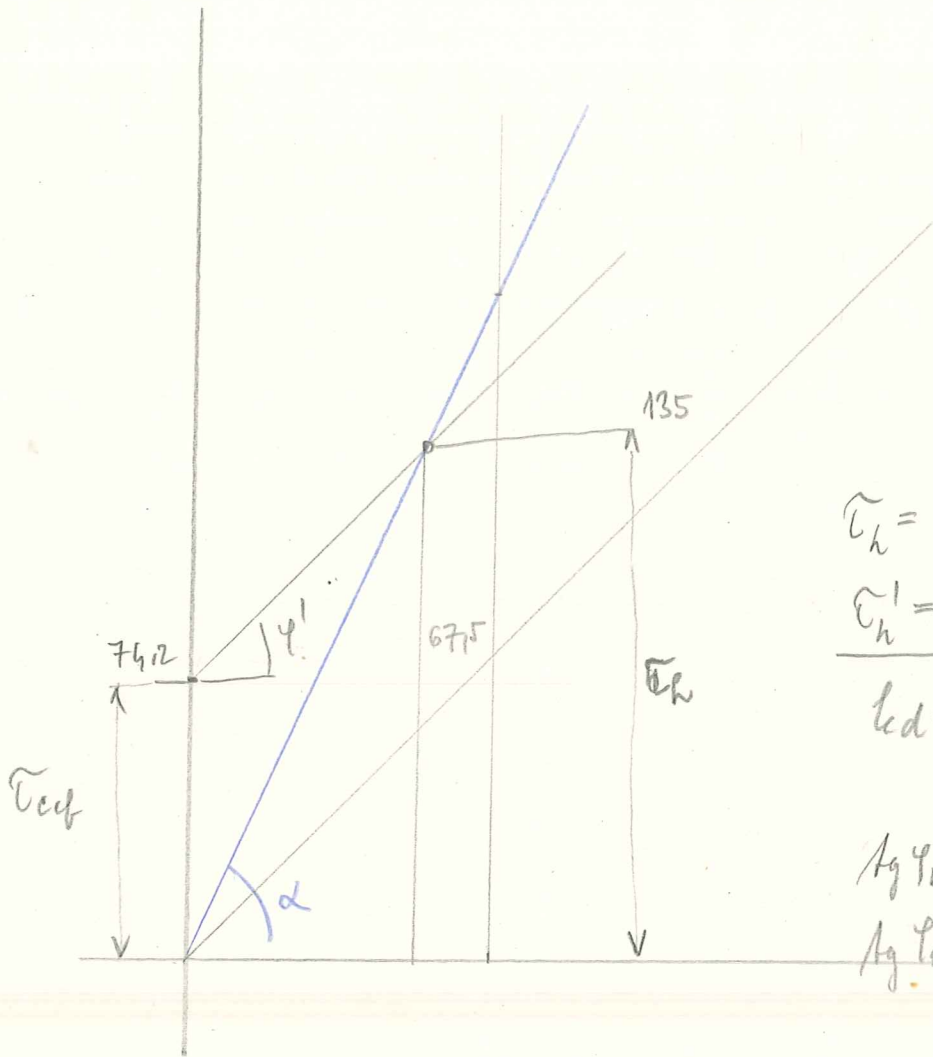
$$W_k = \frac{J_p}{\frac{d}{2}} = \frac{550192}{25} = 22007,68 \text{ mm}^3 = \underline{\underline{22,10 \text{ mm}^3}}$$

$$\sigma_{km} = \frac{M_{km}}{W_k} = \frac{500000}{22000} = 22,7 \text{ MPa}$$

$$\sigma_{ka} = \frac{M_{ka}}{W_k} = \pm \frac{600000}{22000} = 27,3 \text{ MPa}$$

$$\underline{\underline{\sigma_{KR} = \sigma_{km} + \sigma_{ka} = 22,7 + 27,3 = 50 \text{ MPa}}}$$

$$\frac{\sigma_{kk}}{\sigma_m} = \frac{50}{22,7} = 2,2 = \text{Ag} \alpha \quad \alpha = \underline{\underline{65,6^\circ}}$$



$$\sigma_h = 135 \text{ MPa}$$

$$\sigma_h^1 = 50 \text{ MPa}$$

$$k_{ed} = \frac{135}{50} = \underline{\underline{2.7}}$$

Předimenzování

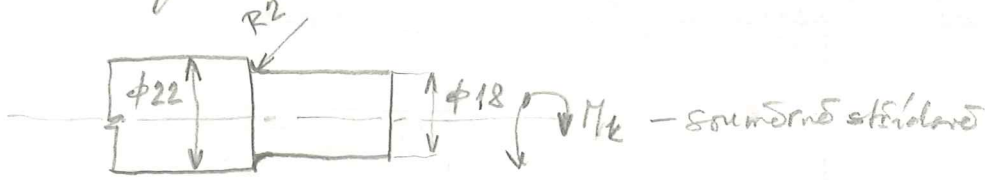
$$A_g \gamma_k = 1$$

$$A_g \gamma_k^1 = 1 + \frac{A_g \gamma_k - 1}{\beta}$$

5

bronzený hřídel

11600



$k_d = ?$ $M_{kmax} = 60 \text{ Nm}$

Musíme kreslit Smithův diagram?

$\tilde{\tau}_{kc} = 0,25 \sigma_{PE}$

$\tau_{kc} = 0,25 \cdot 600 = 150 \text{ MPa}$

$\tilde{\tau}_{kcf} = \tilde{\tau}_{kc} \frac{\epsilon_m \cdot \epsilon_p}{\beta} = 150 \frac{0,9 \cdot 0,95}{1,5} = 85,5 \text{ MPa}$

$\epsilon_m = 0,9$
 $\epsilon_p = 0,95$
 $\beta = 1,5 \left(\frac{R}{d} = \frac{2}{18} = 0,1\bar{1} \right)$

$\tilde{\tau}_{kr} = \frac{M_k}{W_k} = \frac{60000}{1145} = 52,4 \text{ MPa}$

$W_k = \frac{\pi d^3}{16} = \frac{\pi 18^3}{16} = 1145 \text{ mm}^3$

$k_d = \frac{\tilde{\tau}_{kcf}}{\tilde{\tau}_{kr}} = \frac{85,5}{52,4} = \underline{\underline{1,63}}$ VYHOVUJE

6

Kinematika str. 85 příklad 5, 8