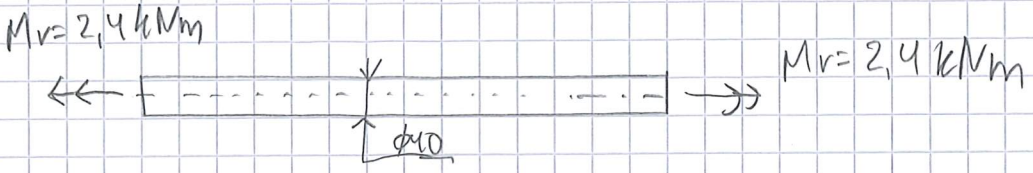
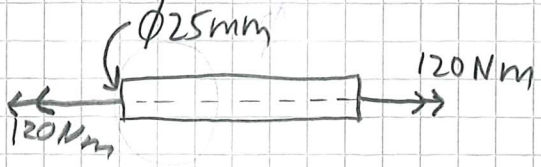
(1)



$$\tau_v = \frac{M_v}{W_v} = \frac{2\,400\,000}{\frac{\pi \cdot 40^3}{16}} \approx 191 \text{ MPa}$$

kap 3.3

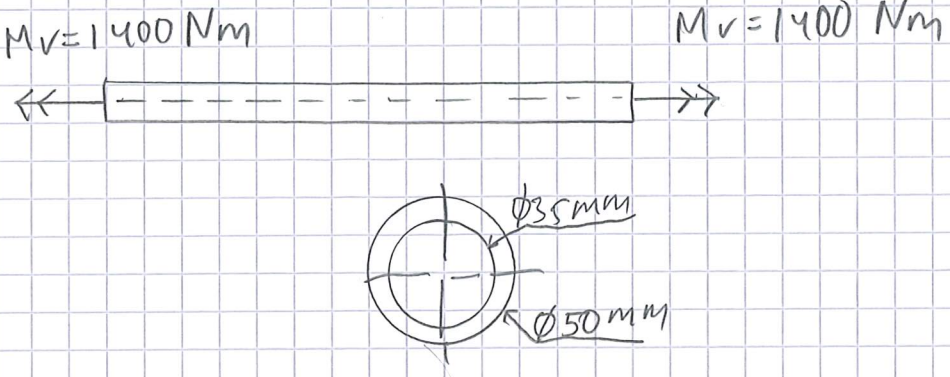
② 

$$\tau_v = \frac{M_v}{W_v} \quad \text{där} \quad W_v = \frac{\pi D^3}{16}$$

$$\tau_v = \frac{120\,000}{\frac{\pi \cdot 25^3}{16}} = 39{,}1 \text{ MPa}$$

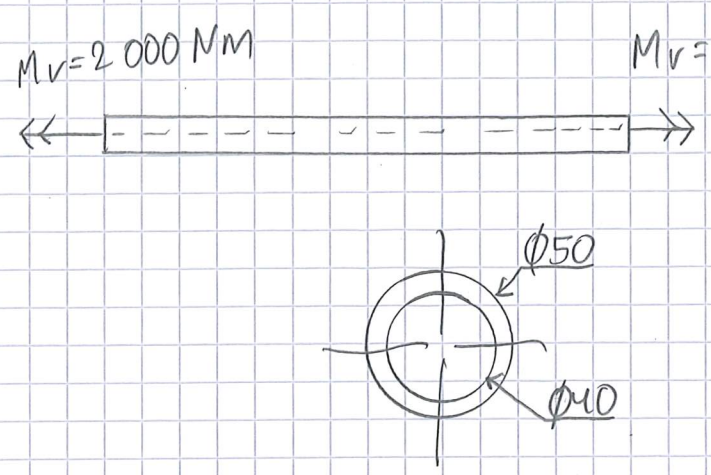
Svar: Vridspänningen blir ca 39 MPa.

(3)



$$\tau_v = \frac{M_v}{W_v} = \frac{1\,400\,000}{\frac{\pi(50^4 - 35^4)}{16 \cdot 50}} \approx 75 \text{ MPa}$$

④



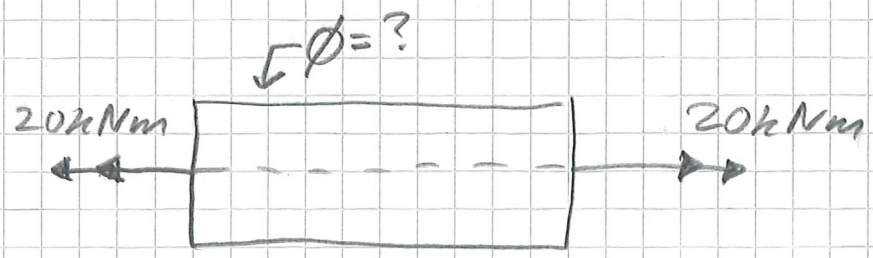
$R_e = 320\ MPa$

$$\tau_{v_{max}} = \frac{M_v}{W_v} = \frac{2\,000\,000}{\frac{\pi(50^4 - 40^4)}{16 \cdot 50}} \approx 138\ MPa$$

$$\tau_{till} = R_e \cdot 0{,}6 = 320 \cdot 0{,}6 = 192\ MPa$$

$$n_v = \frac{\tau_{till}}{\tau_{vmax}} = \frac{192}{138} \approx 1{,}39$$

(5)



$n_s = 2,5$ $\qquad$ $Re = 310 MPa$

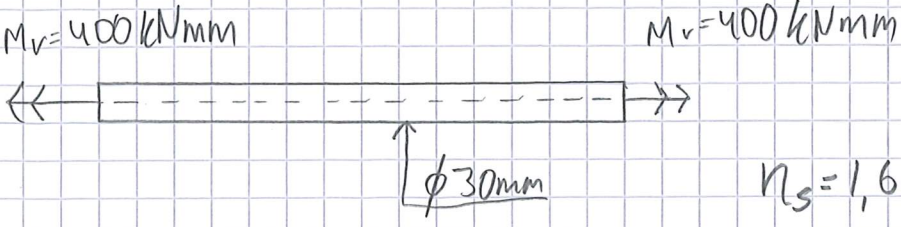
$$\tau_{v\,tillåtet} = \frac{0,6 \cdot Re}{n_s} = \frac{0,6 \cdot 310}{2,5} = 74,4 MPa$$

$$\tau_v = \frac{M_v}{W_v} = \frac{M_v}{\frac{\pi D^3}{16}}$$

$$\Rightarrow D = \sqrt[3]{\frac{16 \cdot M_v}{\pi \tau_{v\,tillåtet}}} = \left(\frac{16 \cdot 20\,000\,000}{\pi \cdot 74,4}\right)^{1/3} = 112,04 mm$$

Välj en diameter på minst 112 mm

(6)

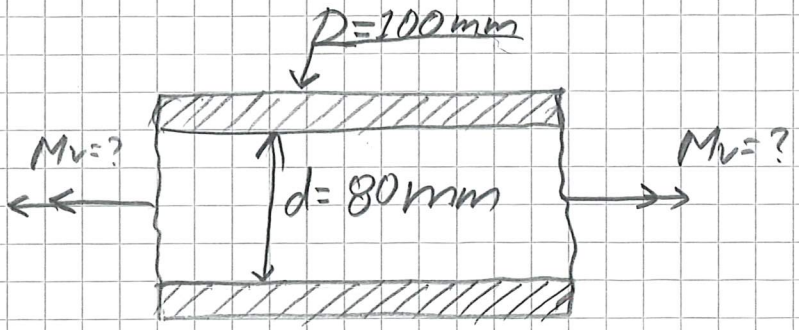


$n_s = 1,6$

$$\tau_{max} = \frac{M_v}{W_v} = \frac{400\,000}{\frac{\pi 30^3}{16}} \approx 75,5\,MPa$$

$$\tau_{max} = \frac{R_e \cdot 0,6}{n_s} \Rightarrow R_e = \frac{\tau_{max} \cdot n_s}{0,6} = \frac{75,5 \cdot 1,6}{0,6} \approx 201,3\,MPa$$

(7)



$n_s = 2$ $\qquad$ $R_e = 310\,MPa$

$$\tau_{v\,till} = \frac{0,6 \cdot R_e}{n_s} = \frac{0,6 \cdot 310}{2} = 93\,MPa$$

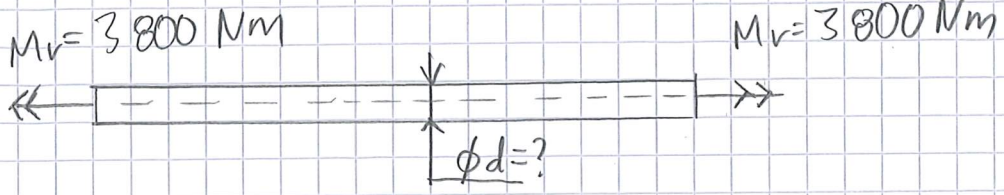
$$\tau_v = \frac{M_v}{W_v} \quad \text{där} \quad W_v = \frac{\pi(D^4 - d^4)}{16D}$$

$$\tau_v = \frac{M_v}{\frac{\pi(D^4 - d^4)}{16D}} \Rightarrow$$

$$M_v = \tau_{v\,till} \cdot \left(\frac{\pi(D^4 - d^4)}{16D}\right) = 93 \cdot \frac{\pi(100^4 - 80^4)}{16 \cdot 100} = 10,8\,kNm$$

Svar: Ca 11 kNm.

(8)



$$R_e = 320 \text{ MPa}, \quad n_s = 1{,}8$$

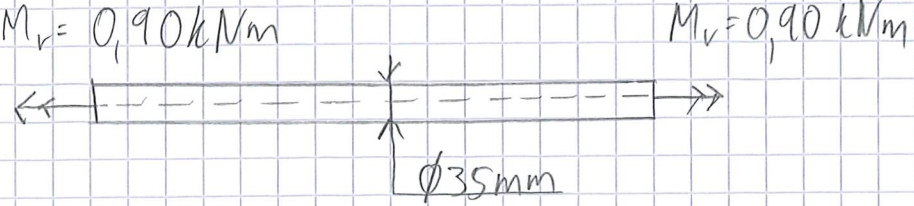
$$\tau_{till} = \frac{R_e \cdot 0{,}6}{n_s} = \frac{320 \cdot 0{,}6}{1{,}8}$$

$$\tau_{till} = \frac{M_v}{W_v} = \frac{M_v}{\frac{\pi \cdot D^3}{16}} \Rightarrow D = \left(\frac{M_v \cdot 16}{\pi \cdot \tau_{till}} \right)^{1/3} =$$

$$D = \left[\frac{3\,800\,000 \cdot 16}{\pi \cdot \frac{320 \cdot 0{,}6}{1{,}8}} \right]^{1/3} \approx 56{,}6 \text{ mm}$$

Välj en diameter på minst 57 mm

(9)



$R_e = 400 MPa$

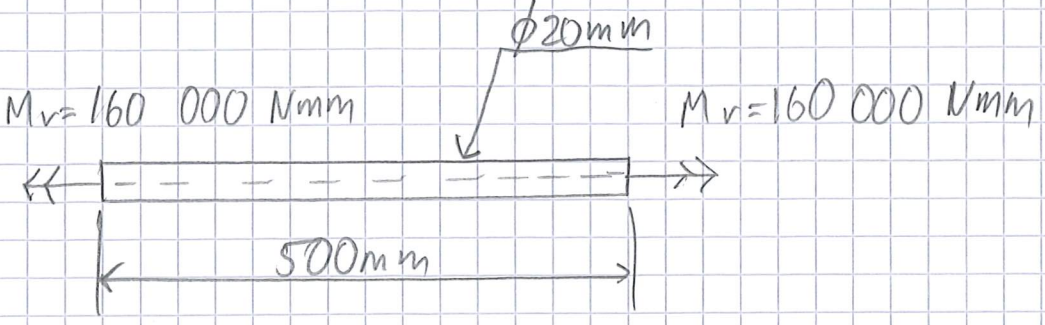
$n_s = ?$

$$\tau_{max} = \frac{M_v}{W_v} = \frac{900\,000}{\frac{\pi \cdot 35^3}{16}} \approx 106,91 MPa$$

$$\tau_{max} = \frac{R_e \cdot 0,6}{n_s} \Rightarrow n_s = \frac{R_e \cdot 0,6}{\tau_{max}} = \frac{400 \cdot 0,6}{106,91} \approx 2,24$$

Svar: cirka 2,2.

(10)



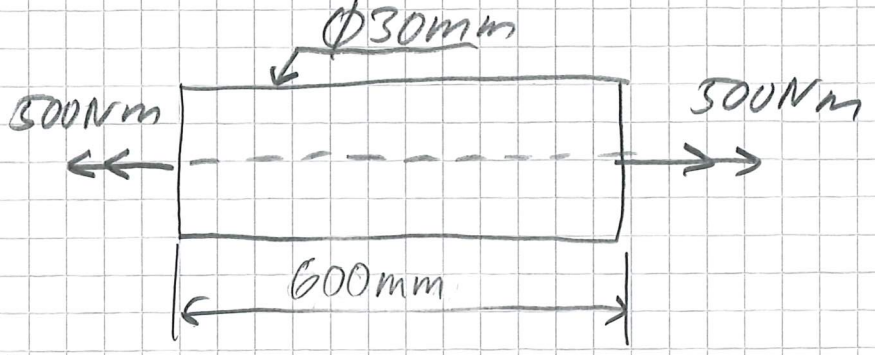
$\Theta = ?$

$G = 80\,000$ MPa

$$\Theta = \frac{M_v \cdot L}{G \cdot I_p} = \frac{160\,000 \cdot 500}{80\,000 \cdot \frac{\pi \cdot 20^4}{32}} \approx 0{,}064 \text{ rad}$$

$$0{,}064 \cdot \frac{180}{\pi} \approx 3{,}65^\circ$$

(11)



$G = 77\,GPa$

Vridspänning

$$\tau_V = \frac{M_V}{W_V} = \frac{500\,000}{\frac{\pi \cdot 30^3}{16}} = 94{,}3\,MPa$$

Förvridning

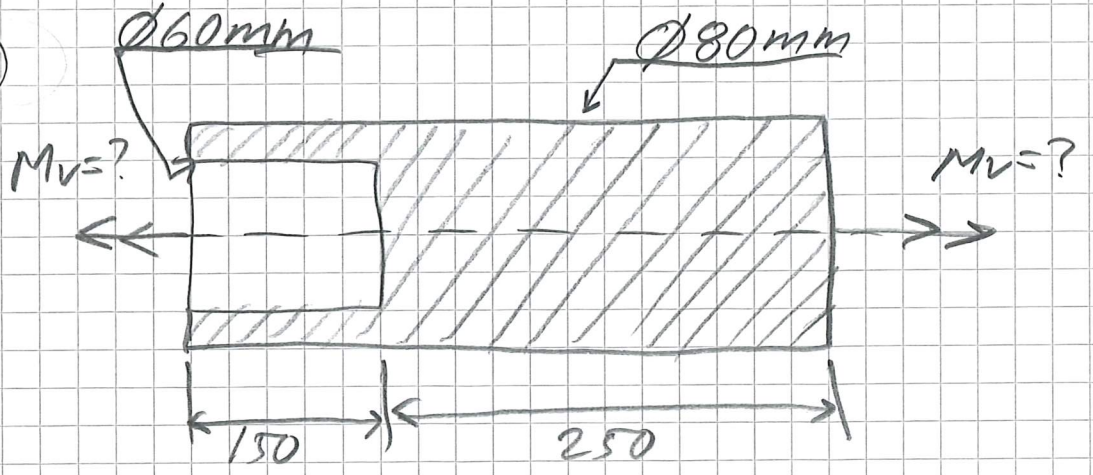
$$\varphi = \frac{M_V \cdot L}{G \cdot I_P}$$

$$I_P = \frac{\pi D^4}{32}$$

$$\Rightarrow \varphi = \frac{500\,000 \cdot 600}{77\,000 \cdot \left(\frac{\pi\, 30^4}{32}\right)} = 0{,}049\ rad$$

$$0{,}049 \cdot \frac{180}{\pi} = 2{,}8^\circ$$

(12)



$G = 2{,}1\,GPa$

$\tau_{v,till} = 5\,MPa$

a) För "stångdelen"

$$\tau_v = \frac{M_v}{W_v} \Rightarrow M_v = \tau_v \cdot W_v = 5 \cdot \frac{\pi 80^3}{16} = 502{,}654\,Nm$$

För "röret"

$$M_v = 5 \cdot \frac{\pi(80^4 - 60^4)}{16 \cdot 80} = 343{,}6\,Nm$$

Maxmomentet är <u>340Nm</u>

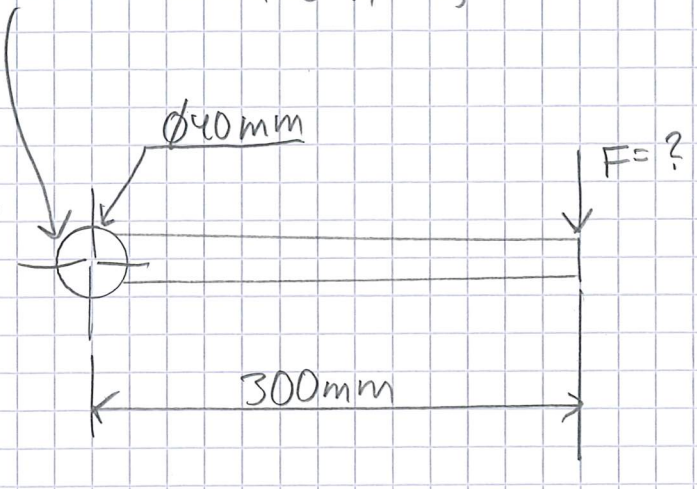
b) $$\varphi = \frac{M_v}{G}\left(\frac{L_{rör}}{I_{rör}} + \frac{L_{stång}}{I_{stång}}\right) =$$

$$= \frac{343612}{2100}\left(\frac{150}{\frac{\pi \cdot (80^4 - 60^4)}{32}} + \frac{250}{\frac{\pi \cdot 80^4}{32}}\right) = 0{,}0191\,rad$$

Förvridningen är cirka 1,1°

(13)

$R_e = 420\,MPa$ och $n_s = 1{,}5$



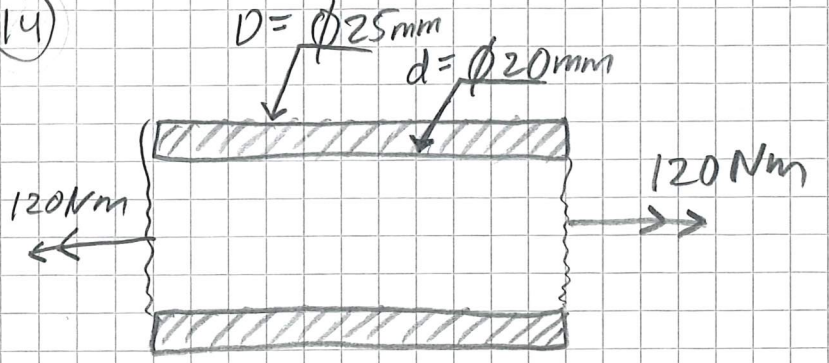
$$\tau_{till} = \frac{R_e \cdot 0{,}6}{n_s} = \frac{420 \cdot 0{,}6}{1{,}5} = 168\,MPa$$

$$\tau_{till} = \frac{M_v}{W_v} = \frac{M_v}{\frac{\pi \cdot 40^3}{16}} \Rightarrow$$

$$\Rightarrow M_v = \tau_{till} \cdot \frac{\pi \cdot 40^3}{16} \quad \text{där } M_v = F \cdot 300$$

$$\Rightarrow F = \tau_{till} \cdot \frac{\pi \cdot 40^3}{16 \cdot 300} = \frac{168 \cdot \pi \cdot 40^3}{16 \cdot 300} \approx 7037\,N$$

(14)



$$W_v = \frac{\pi(D^4 - d^4)}{16 \cdot D}$$

$$\tau_{v_{max}} = \frac{M_v}{W_v} = \frac{120\,000}{\frac{\pi(25^4 - 20^4)}{16 \cdot 25}} = 66{,}25 \text{ MPa} \quad \text{(ytterst)}$$

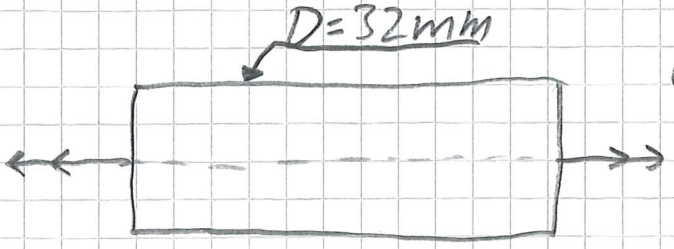
Om vridspänningen antas öka linjärt från centrum ger inner-vridspänningen av:

$$\frac{\tau_{v_{inner}}}{20} = \frac{\tau_{v_{max}}}{25}$$

$$\tau_{v_{inner}} = 20 \cdot \frac{\tau_{v_{max}}}{25} = \frac{20 \cdot 66{,}25}{25} = 53 \text{ MPa}$$

Svar: Maximala vridspänningen blir ca 66 MPa och uppstår ytterst. Vridspänningen på insidan blir ca: 53 MPa.

(15)



$$M_v = \frac{P}{\omega} = \frac{40\,000}{\frac{\pi \cdot 2800}{30}} = 136{,}4\,Nm$$

$R_e = 310\,MPa$

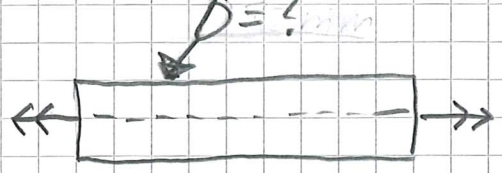
$n_s = ?$

$$\tau_v = \frac{M_v}{W_v} = \frac{136\,419}{\frac{\pi \cdot 32^3}{16}} = 21{,}2\,MPa$$

$$n_s = \frac{0{,}6 \cdot R_e}{\tau_v} = \frac{0{,}6 \cdot 310}{21{,}2} = 8{,}774$$

Svar: Säkerheten är ca: 8.8 mot sträckning.

(16)



$$M_v = \frac{P}{\omega} = \frac{250 \cdot 735}{\frac{\pi \cdot 3500}{30}} = 501,5 \text{ Nm}$$

$n_s = 3$ $\qquad$ $R_e = 310 \text{ MPa}$

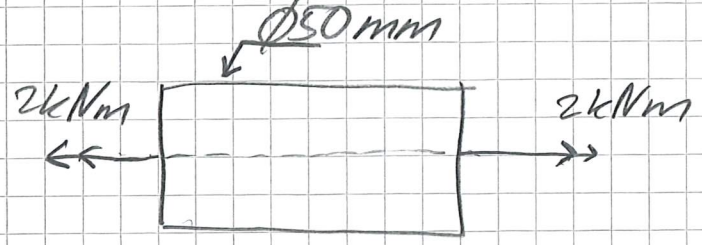
$$\tau_v = \frac{M_v}{W_v} = \frac{M_v}{\frac{\pi D^3}{16}} \quad \text{och} \quad \tau_{v\,till} = \frac{0,6 \cdot R_e}{n_s}$$

$$\Rightarrow \frac{0,6 \cdot R_e}{n_s} = \frac{M_v}{\frac{\pi D^3}{16}}$$

$$\Rightarrow D = \sqrt[3]{\frac{M_v \cdot n_s \cdot 16}{0,6 \cdot R_e \cdot \pi}} = \sqrt[3]{\frac{501592 \cdot 3 \cdot 16}{0,6 \cdot 310 \cdot \pi}} = 34,53 \text{ mm}$$

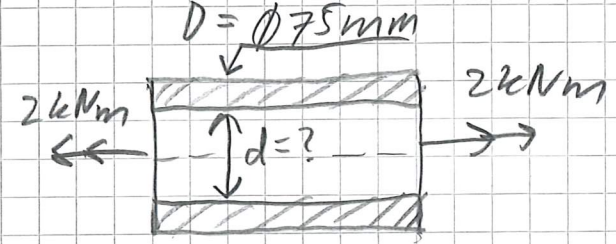
Svar: Välj en axel på minst 35 mm.

(17)



$\tau_v = ?$

$$\tau_v = \frac{M_v}{W_v} = \frac{2\,000\,000}{\frac{\pi 50^3}{16}} = \underline{81{,}5 \text{ MPa}}$$



$$\tau_v = \frac{M_v}{W_v} \Rightarrow 81{,}5 = \frac{2\,000\,000}{\frac{\pi (D^4 - d^4)}{16D}} \quad \text{där } D = 75\text{mm}$$

Lös ut och beräkna d

$\Rightarrow d = \underline{68{,}7 \text{ mm}}$

densitet

Vikt för stång per meter $= \frac{\pi 50^2}{4} \cdot 1000 \rho$ [kg]

Vikt för rör per meter $= \frac{\pi}{4}(75^2 - 68{,}7^2) \cdot 1000 \cdot \rho$

Skillnad $\Rightarrow \frac{\frac{\pi}{4}(75^2 - 68{,}7^2) \cdot 1000\rho}{\frac{\pi}{4} 50^2 \cdot 1000\rho} = \frac{75^2 - 68{,}7^2}{50^2} = 0{,}36$

Rör-axeln är 64 procent lättare.

(18)

$$P_{ut} = P_{in} \cdot \eta = 12 \cdot 0{,}97 = 11{,}64 \approx \underline{\underline{12{,}64\,kW}}$$

(in) $$M_v = \frac{P_{in}}{\omega_{in}} = \frac{12\,000}{\frac{\pi\,3000}{30}} = 38{,}2 \approx \underline{\underline{38\,Nm}}$$

(ut) $$M_v = \frac{P_{ut}}{\omega_{ut}} = \frac{11640}{\frac{\pi \cdot 3000}{30} \cdot (1/3)} = 111{,}15 \approx \underline{\underline{111\,Nm}}$$

(1/3 ↑ utväxling)

$\tau_{till} = 60\,MPa$

(inaxel) $\tau_{tin} = \frac{M_v}{W_v}$ där $W_v = \frac{\pi D^3}{16}$

$$\Rightarrow \quad \frac{\pi D^3}{16} = \frac{M_v}{\tau_{till}} \quad \text{och}$$

$$D = \sqrt[3]{\frac{M_v \cdot 16}{\pi \cdot \tau_{till}}} = \sqrt[3]{\frac{38\,000 \cdot 16}{\pi \cdot 60}} = 14{,}78 \approx \underline{\underline{15\,mm}}$$

(utaxel)

$$\Rightarrow \quad D = \sqrt[3]{\frac{111\,000 \cdot 16}{\pi \cdot 60}} = 21{,}12 \approx \underline{\underline{22\,mm}}$$

(19) Ingående axel (motorsidan)

$P_{in} = 100 \text{ hk} = 100 \cdot 735{,}5 = 73\,550 \text{ W}$

$\omega_{in} = \frac{\pi \cdot 3\,000}{30} = 100\pi \text{ rad/s}$

$\tau_{till} = \frac{R_c \cdot 0{,}6}{n_s} = \frac{310 \cdot 0{,}6}{3{,}5} \approx 53{,}14 \text{ MPa}$

$M_v = \frac{P_{in}}{\omega_{in}} = \frac{73\,550}{100\pi} \approx 234{,}1 \text{ Nm}$

$\tau_v = \frac{M_v}{W_v} = \frac{M_v}{\frac{\pi D^3}{16}} \Rightarrow D_{in} = \left(\frac{M_v \cdot 16}{\pi \cdot \tau_v}\right)^{1/3} =$

$\tau_v = \tau_{till}$

$= \left(\frac{234\,100 \cdot 16}{\pi \cdot 53{,}14}\right)^{1/3} \approx 28{,}2 \text{ mm}$

Svar: Välj en ingående axel på minst 28,2 mm.

Utgående axel

$\omega_{ut} = \frac{\omega_{in}}{\text{utväxling}} = \frac{100\pi}{12{,}3} \approx 25{,}54 \text{ rad/s}$

$P_{ut} = P_{in} \cdot 0{,}95 = 73\,550 \cdot 0{,}95 \approx 69\,872{,}5 \text{ W}$

$M_{vut} = \frac{P_{ut}}{\omega_{ut}} = \frac{69\,872{,}5}{25{,}54} \approx 2735{,}81 \text{ Nm}$

$\tau_v = \frac{M_{vut}}{W_v} = \frac{M_v}{\frac{\pi \cdot D_{ut}^3}{16}} \Rightarrow D_{ut} = \left(\frac{M_{vut} \cdot 16}{\pi \cdot \tau_v}\right)^{1/3} =$

$= \left(\frac{2\,735\,810 \cdot 16}{\pi \cdot 53{,}14}\right)^{1/3} \approx 64 \text{ mm}$

Svar: Välj en axel på minst 64 mm.

(20) Dubbla vridmomentet.

- Vridspänning

båda axlarna har samma vridspänning.

$$\tau_v = \frac{M_{v1}}{W_{v1}} = \frac{M_{v2}}{W_{v2}} \Rightarrow$$

$$\frac{M_{v1} \cdot 16}{\pi \cdot d_1^3} = \frac{2 M_{v1} \cdot 16}{\pi d_2^3}$$ Förkorta bort M_{v1}, 16 och π

$$\frac{1}{d_1^3} = \frac{2}{d_2^3} \Rightarrow \frac{d_2}{d_1} = \sqrt[3]{2} = 1{,}260$$

Diametern ökas 26%

- Båda axlarna har samma förvridning.

$$\varphi = \frac{M_{v1} \cdot L}{G \cdot I_{p1}} = \frac{M_{v2} \cdot L}{G \cdot I_{p2}} \Rightarrow$$

$$\frac{M_{v1} \cdot L}{G \cdot \frac{\pi d_1^4}{32}} = \frac{2 M_{v1} \cdot L}{G \cdot \frac{\pi d_2^4}{32}}$$ Förkorta bort M_{v1}, L, G

$$\Rightarrow \frac{d_2}{d_1} = \sqrt[4]{2} = 1{,}189$$

Diametern ökar cirka 19 Procent