TRANSPORTNI UREĐAJI
VJEŽBE - 13

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INFORMACIJE

-POSLJEDNJE VJEŽBE !!!!

-Za sve informacije – mail, konzultacije

-2. KOLOKVIJ

- 01.06.2011. – 12:00 – B dvorana

- ANKETA !!!!!

ZADATAK 28 (1)

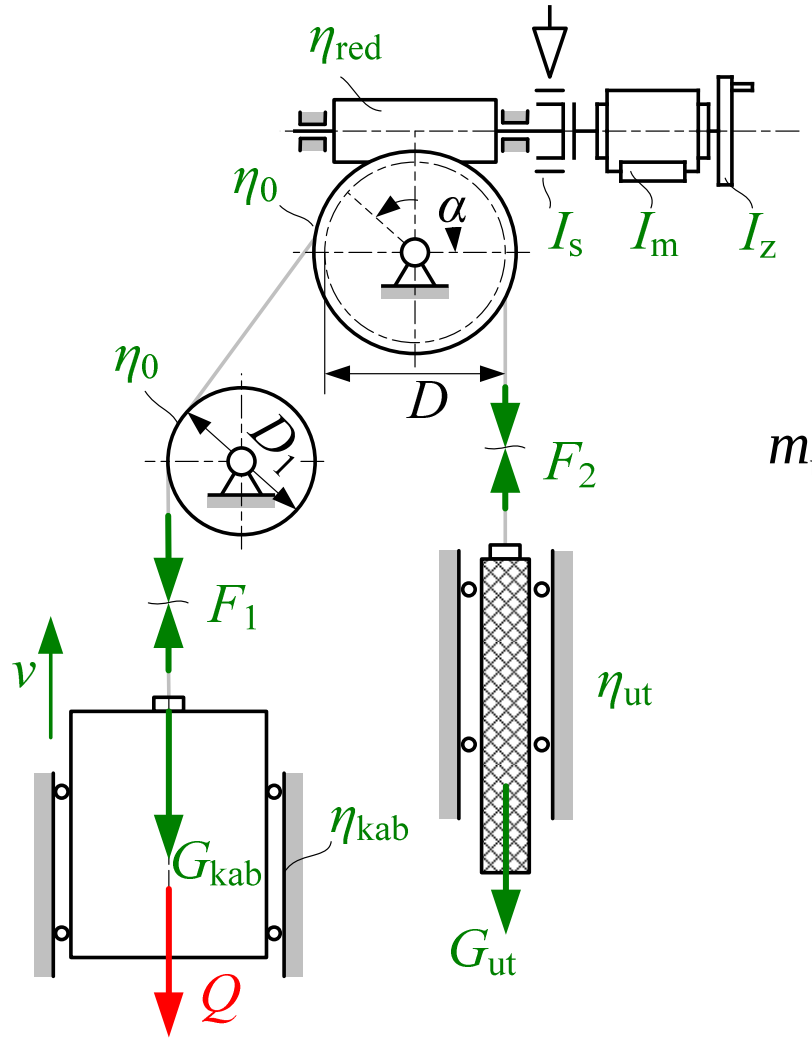
Za pogonski mehanizam lifta prema slici zadano je:
nosivost m = 450 kg; masa kabine m_{kab} = 700 kg;
masa utega m_{ut} = 925 kg;
D = 550 mm ($D/d \geq 50$); D_1 = 360 mm ($D_1/d \geq 35$);
h = 37,5 m (visina dizanja); $l_{už}$ = 40 m (najveća viseća dužina užeta);
$\alpha = (8/9)\pi$; $\gamma = (2/9)\ \pi$ (trapezni utor užnice);
η_{red} = 0,65 (pužni reduktor); η_0 = 0,98 (užnica);
gubici vođenja kabine su (2 do 5) %, odabrano η_{kab} = 0,96;
gubici vođenja utega su (1 do 3) %, odabrano η_{ut} = 0,98.
Elektromotor: "RK" 5ALV 160 MA-4/16; kW, M_n = 56 Nm; $M_p \approx 2{,}3M_n$;
ω_{EM} = 142,8 s^{-1}; I_{EM} = 0,115 kgm^2; s prisilnim hlađenjem, 180 ukapčanja/h.
Reduktor: "RK" W - 160, ired = 36. Spojka s bubnjem kočnice: IS = 0,2 kgm2.
Čelično uže: Uže 10 DIN 3062 - FE - bk 1570 sZ, lift ima 4 užeta.
Značajke užeta: d = 10 , Seal 8×(1+9+9);
računska lomna sila $F_L = 537d^2$, N (d, mm); $q_m = 0{,}00348d^2$ kg/m (d, mm). Sigurnost užeta: $S \geq 14$.

ZADATAK 28 (2)

Potrebno je provesti kontrolni proračun elemenata pogonskog mehanizma te kinematičkih i dinamičkih značajki sustava:

- provjeriti dimenzioniranje utega, užeta i motora;
- izračunati brzinu dizanja s ugrađenim komponentama;
- izračunati potrebni moment inercije zamašnjaka I_z tako da usporenje pri kočenju pune kabine prema gore ne premaši 0,75 m/s^2;
- izračunati vrijeme pokretanja pune kabine prema gore (s najniže postaje) i vrijeme kočenja pune kabine prema dolje (pred najnižom postajom);
- provjeriti sigurnost protiv proklizavanja vučnog pogona pri ustaljenoj vožnji s punom i praznom kabinom te pri pokretanju i kočenju s punom kabinom;
- izračunati granično usporenje pri kočenju s punom kabinom prema dolje kod kojeg bi sigurnost protiv proklizavanja bila jednaka 1.

ZADATAK 28 (3)



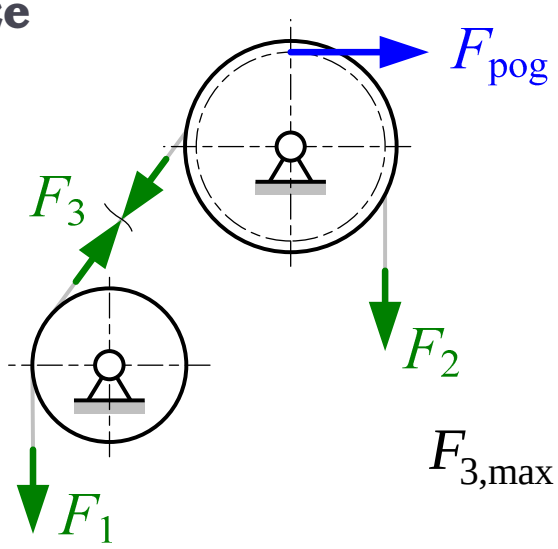
Masa utega

$$m_{ut} = m_{kab} + m/2 = 700 + 450/2 = 925\,\text{kg}$$

Masa utega je dobro izabrana

ZADATAK 28 (4)

Uže



$$F_{3,\max} = \frac{F_1}{\eta_0} = \left(\frac{Q + G_{kab}}{\eta_{kab}} + G_{už} \right) \frac{1}{\eta_0}$$

$$F_{3,\max} = \left(\frac{4414,5 + 6867}{0,96} + 546,2 \right) \frac{1}{0,98} = 12548,8\,\text{N}$$

Maksimalna statička sila u jednom užetu (kabina visi na 4 užeta)

$$F_{st,\max} = \frac{F_{3,\max}}{4} = \frac{12548,8}{4} = 3137,2\,\text{N}$$

Statički faktor sigurnosti

$$S = \frac{F_L}{F_{st,\max}} = \frac{537\,d^2}{F_{st,\max}} = \frac{537 \cdot 10^2}{3137,2} = 17,1 > 14$$

zadovoljava

ZADATAK 28 (5)

Brzina dizanja

$$i_{\text{meh}} = \frac{\omega_{\text{EM}}}{v_{\text{diz}}} = \frac{i_{\text{red}}}{R} \quad \Rightarrow \quad v_{\text{diz}} = \frac{\omega_{\text{EM}}}{i_{\text{red}}} R = \frac{142,8}{36} \cdot 0,275 = 1,09$$

$$v_{\text{puz}} = v_{\text{diz}} / 4 = 1,09 / 4 = 0,273$$

ZADATAK 28 (6)

Snaga motora

Najveća obodna sila na pogonskoj užnici javlja se kada je razlika sila najveća

$$P_{\mathrm{n}} = (1{,}1 \text{ do } 1{,}2)\frac{F_{\mathrm{pog}}\, v_{\mathrm{diz}}}{\eta_{\mathrm{meh}}}$$

$$F_{\mathrm{pog}} = F_{3,\max} - F_{2,\min} \qquad \eta_{\mathrm{meh}} = \eta_0\, \eta_{\mathrm{red}} = 0{,}98 \cdot 0{,}65 = 0{,}637$$

$$F_{2,\min} = G_{\mathrm{ut}}\, \eta_{\mathrm{ut}} = m_{\mathrm{ut}}\, g\, \eta_{\mathrm{ut}} = 925 \cdot 9{,}81 \cdot 0{,}98 = 8892{,}8\,\mathrm{N}$$

$$F_{\mathrm{pog}} = F_{3,\max} - F_{2,\min} = 12548{,}8 - 8892{,}8 = 3656\,\mathrm{N}$$

$$P_{\mathrm{n}} = 1{,}15 \cdot \frac{3656 \cdot 1{,}09}{0{,}637} = 7200\,\mathrm{W}$$

Zaključak: motor od 8 kW odgovara

ZADATAK 28 (7)

Provjera sigurnosti vučnoga pogona za statičko stanje

$$\mu = \frac{\mu_0}{\sin(\gamma/2)} = \frac{0,09}{\sin(\pi/9)} = 0,263$$

a) Vožnja s punom kabinom prema gore

Radni obuhvatni kut

$$\alpha_{r,1} = \frac{1}{\mu}\ln\left[\frac{F_{3,max}}{F_{2,min}}\right] = \frac{1}{0,263}\ln\left[\frac{12548,8}{8892,8}\right] = 1,31\,\text{rad} = 75°$$

Sigurnost vučnog pogona

$$S_{v,1} = \frac{e^{\mu\alpha} - 1}{e^{\mu\alpha_{r,s}} - 1} = \frac{e^{0,263\cdot(8/9)\pi} - 1}{e^{0,263\cdot 1,31} - 1} = 2,64$$

ZADATAK 28 (8)

b) Vožnja s praznom kabinom prema dolje

$$F_{3,\min} = G_{\text{kab}}\,\eta_{\text{kab}}\,\eta_0 = 6867 \cdot 0,96 \cdot 0,98 = 6460,5$$

$$F_{2,\max} = G_{\text{ut}} / \eta_{\text{ut}} + G_{\text{už}} = 925 \cdot 9,81 / 0,98 + 546,2 = 9805,66$$

$$\alpha_{\text{r},2} = \frac{1}{\mu} \ln\left[\frac{F_{2,\max}}{F_{3,\min}}\right] = \frac{1}{0,263} \ln\left[\frac{9805,66}{6460,47}\right] = 1,586\,\text{rad} = 90,85°$$

$$\text{S}_{\text{v},2} = \frac{e^{\mu\alpha} - 1}{e^{\mu\alpha_{\text{r},2}} - 1} = \frac{e^{0,263 \cdot (8/9)\pi} - 1}{e^{0,263 \cdot 1,586} - 1} = 2,096$$

ZADATAK 28 (9)

Dinamička analiza - moment inercije zamašnjaka

$$I_{\text{uk}} = I_{\text{rot}} + I_{\text{tran}} + I_{\text{z}}$$

$$I_{\text{rot}} = 1{,}15 \cdot \left(I_{\text{EM}} + I_{\text{S}} \right) = 1{,}15 \cdot \left(0{,}115 + 0{,}2 \right) = 0{,}362$$

$$I_{\text{tra}} = \frac{m_{\text{tra}}}{\eta_{\text{meh}}\, i_{\text{meh}}^2} = \frac{2161}{0{,}637 \cdot 130{,}91^2} = 0{,}198$$

$$m_{\text{tra}} = \frac{m_{\text{kab}} + m}{\eta_{\text{kab}}} + \frac{m_{\text{už}}}{\eta_0} + m_{\text{ut}}\, \eta_{\text{ut}} = \left(\frac{700 + 450}{0{,}96} + \frac{55{,}68}{0{,}98} + 925 \cdot 0{,}98 \right) = 2161$$

ZADATAK 28 (10)

Dinamička analiza - moment inercije zamašnjaka

$$I_{\text{uk}} = \frac{M_{\text{k}} + M_{\text{st}}}{i_{\text{meh}}\, a_{\text{k}}} = \frac{128{,}8 + 43{,}84}{130{,}91 \cdot 0{,}75} = 1{,}759$$

$$M_{\text{k}} = 2{,}3 M_{\text{n}} = 2{,}3 \cdot 56 = 128{,}8 \text{ Nm}$$

$$M_{\text{st}} = \frac{F_{\text{pog}}}{i_{\text{meh}}\, \eta_{\text{meh}}} = \frac{3656}{130{,}91 \cdot 0{,}637} = 43{,}84 \text{ Nm}$$

$$I_{\text{z}} = I_{\text{uk}} - (I_{\text{rot}} + I_{\text{tran}}) = 1{,}759 - (0{,}362 + 0{,}198) = 1{,}2$$

ZADATAK 28 (11)

Vrijeme pokretanja pune kabine prema gore

Jednadžba gibanja pri pokretanju pune kabine prema gore glasi

$$I_{\text{uk}}\,\varepsilon_{\text{p}} = M_{\text{p}} - M_{\text{st}}$$

$$\varepsilon_{\text{p}} = \frac{M_{\text{p}} - M_{\text{st}}}{I_{\text{uk}}} = \frac{128,8 - 43,84}{1,759} = 48,3 \text{ rad/s}^2$$

$$a_{\text{p}} = \frac{\varepsilon_{\text{p}}}{i_{\text{meh}}} = \frac{48,3}{130,91} = 0,369$$

$$t_{\text{p}} = \frac{v_{\text{diz}}}{a_{\text{p}}} = \frac{1,09}{0,3369} = 2,95$$

ZADATAK 28 (12)

Kočenje pune kabine prema dolje, bez otpora vođenja

Vrijeme kočenja s elektromotorom od radne brzine do brzine puzanja

$$t_{k,1} = \frac{v_{diz} - v_{puz}}{a_k}$$

Jednadžba gibanja

$$I_{uk,k}\,\varepsilon_k = M_k - M_{st,k} \quad \Rightarrow \quad \varepsilon_k = i_{meh}\,a_k = \frac{M_k - M_{st,k}}{I_{uk,k}}$$

$$a_k = \frac{M_k - M_{st,k}}{I_{uk,k}\,i_{meh}}$$

ZADATAK 28 (13)

Statičko opterećenje vratila motora

$$M_{\mathrm{st,k}} = \frac{F_{\mathrm{k}}}{i_{\mathrm{meh}}} \eta_{\mathrm{meh,k}} = \frac{2517}{130,91} 0,452 = 8,7$$

$$\eta_{\mathrm{meh,k}} = \left(2 - 1/\eta_{\mathrm{red}}\right)\left(2 - 1/\eta_0\right) = \left(2 - 1/0,65\right)\left(2 - 1/0,98\right) = 0,452$$

Sila na obodu pogonske užnice (bez otpora vođenja)

$$F_{\mathrm{k}} = F_3 - F_2 = (m_{\mathrm{kab}} + m + m_{\mathrm{už}})\, g\, \eta_0 - m_{\mathrm{ut}}\, g$$

$$F_{\mathrm{k}} = \left[(700 + 450 + 55,68) \cdot 0,98 - 925\right] \cdot 9,81 = 2517$$

Nakon uvrštavanja slijedi: $t_{\mathrm{k},1} = 1,44$

ZADATAK 28 (14)

Djelovanje mehaničke kočnice

Pretpostavka:

moment kočenja mehaničke kočnice $M_{\mathrm{k,meh}} = 2M_{\mathrm{n}} = 112$ Nm

$$t_{\mathrm{k,meh}} = \frac{v_{\mathrm{puz}}}{a_{\mathrm{k,meh}}} \qquad s_{\mathrm{k,meh}} = \frac{v_{\mathrm{puz}}\, t_{\mathrm{k,meh}}}{2}$$

$$a_{\mathrm{k,meh}} = \frac{M_{\mathrm{k,meh}} - M_{\mathrm{st,k}}}{I_{\mathrm{uk,k}}\, i_{\mathrm{meh}}}$$

ZADATAK 28 (15)

Djelovanje mehaničke kočnice

statičko opterećenje vratila motora

$$M_{\mathrm{st,k}} = \frac{F_{\mathrm{k}}}{i_{\mathrm{meh}}} \eta_{\mathrm{meh,k}} = \frac{2517}{130,91} 0,452 = 8,7$$

$$\eta_{\mathrm{meh,k}} = \left(2 - 1/\eta_{\mathrm{red}}\right)\left(2 - 1/\eta_{0}\right) = 0,452$$

$$I_{\mathrm{uk,k}} = I_{\mathrm{z}} + I_{\mathrm{rot}} + \frac{m_{\mathrm{tra,k}}}{i_{\mathrm{meh}}^{2}} \eta_{\mathrm{meh,k}} = 1,616$$

Nakon uvrštavanja

$$a_{\mathrm{k,meh}} = 0,488 \qquad t_{\mathrm{k,meh}} = 0,558 \qquad s_{\mathrm{k,meh}} = 0,076$$

ZADATAK 28 (16)

Sigurnost vučnog pogona pri pokretanju i kočenju

Pokretanje s punom kabinom prema gore

$$F_{\text{pog,p}} = F_{3,\text{p,max}} - F_{2,\text{p,min}} = 13003 - 8551 = 4452$$

$$F_{3,\text{p,max}} = F_{3,\text{max}} + (m_{\text{kab}} + m + m_{\text{už}})\, a_{\text{p}} \frac{1}{\eta_0} \qquad F_{2,\text{p,min}} = m_{\text{ut}}\, g\, \eta_{\text{ut}} - m_{\text{ut}}\, a_{\text{p}}$$

Obuhvatni kut potreban za ovu obodnu silu je

$$\alpha_{\text{p}} = \frac{1}{\mu} \ln\left[\frac{F_{3,\text{p,max}}}{F_{2,\text{p,min}}}\right] = \frac{1}{0,263} \ln\left[\frac{13003}{8551}\right] = 1,593\,\text{rad} = 91,25°$$

sigurnost vučnog prijenosa $$S_{\text{v,p}} = \frac{e^{\mu\alpha} - 1}{e^{\mu\alpha_{\text{p}}} - 1} = \frac{e^{0,263\cdot(8/9)\pi} - 1}{e^{0,263\cdot 1,593} - 1} = 2,08$$

ZADATAK 28 (17)

Kočenje s punom kabinom prema dolje

$$F_{3,k,max} = (m_{kab} + m + m_{už})(g + a_k)\eta_0$$

$$F_{3,k,max} = (700 + 450 + 55,68) \cdot (9,81 + 0,568) \cdot 0,98 = 12262$$

$$F_{2,k,min} = m_{ut}(g - a_k) = 925 \cdot (9,81 - 0,568) = 8549$$

$$F_k = F_{3,k,max} - F_{2,k,min} = 12262 - 8549 = 3713$$

$$\alpha_k = \frac{1}{\mu} \ln\left[\frac{F_{3,k,max}}{F_{2,k,min}}\right] = \frac{1}{0,263} \ln\left[\frac{12262}{8549}\right] = 1,37\,\text{rad} = 78,54°$$

$$S_{v,k} = \frac{e^{\mu\alpha} - 1}{e^{\mu\alpha_k} - 1} = \frac{e^{0,263 \cdot (8/9)\pi} - 1}{e^{0,263 \cdot 1,37} - 1} = 2,5$$

ZADATAK 28 (18)

Granično usporenje pri kočenju

$$F_{3,\mathrm{gr}} = (m_{\mathrm{kab}} + m + m_{\mathrm{už}})(g + a_{\mathrm{gr}})\eta_0 \qquad F_{2,\mathrm{gr}} = m_{\mathrm{ut}}(g - a_{\mathrm{gr}})$$

Iz jednakosti sila mora vrijediti:

$$(m_{\mathrm{kab}} + m + m_{\mathrm{už}})(g + a_{\mathrm{gr}})\eta_0 = m_{\mathrm{ut}}(g - a_{\mathrm{gr}})e^{\mu\alpha}$$

$$a_{\mathrm{gr}} = \frac{m_{\mathrm{ut}}\, e^{\mu\alpha} - (m_{\mathrm{kab}} + m + m_{\mathrm{už}})\eta_0}{m_{\mathrm{ut}}\, e^{\mu\alpha} + (m_{\mathrm{kab}} + m + m_{\mathrm{už}})\eta_0} g$$

$$a_{\mathrm{gr}} = \frac{925 \cdot e^{0{,}263\cdot(8/9)\pi} - (700 + 450 + 55{,}68)\cdot 0{,}98}{925 \cdot e^{0{,}263\cdot(8/9)\pi} + (700 + 450 + 55{,}68)\cdot 0{,}98} \cdot 9{,}81 = 2{,}357$$