MECANISME

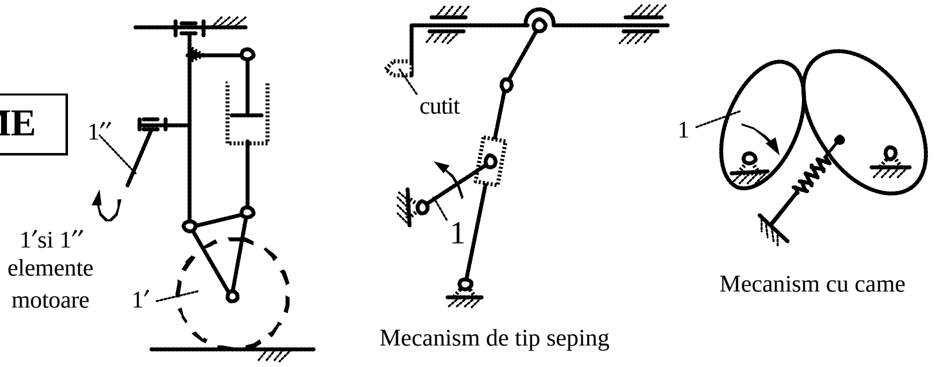
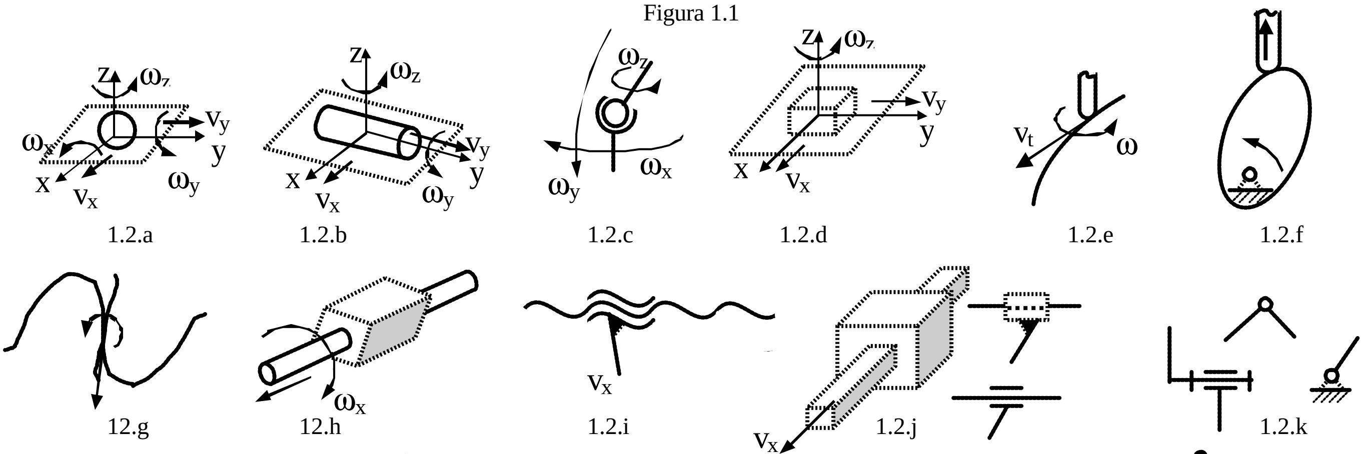


Figura 1.1



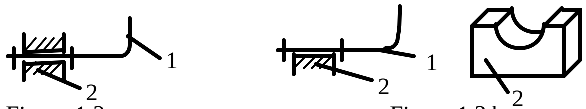


Figura 1.3.a Figura.1.3.b

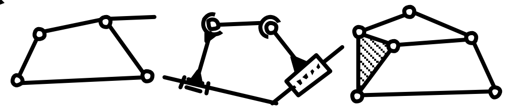


Figura 1.4

Clasificarea lanturilor cinematice este prezentata în Tabelul 1.1. Rangul "j" al unui element este egal cu numarul cuplelor cinematice cu care acesta se leaga de alte elemente.

Tabelul 1.1

Dupa complexitatea miscarii	Lanturi cinematice plane	Toate elementele au miscari într-un singur plan sau în plane paralele
	Lanturi cinematice spatiale	Miscarile elementelor au loc în plane diferite
Dupa numarul cuplelor cinematice care revin unui element cinematic	Lanturi cinematice simple	Fiecare element are j ≤ 2
	Lanturi cinematice complexe	Cel putin un element are j ≥ 3
	Lanturi cinematice închise	Toate elementele au j ≥ 2
	Lanturi cinematice deschise	Cel putin un element are j = 1

$$L = 6 \cdot n - \sum_{k=1}^{5} k \cdot C_k \qquad (1.1)$$

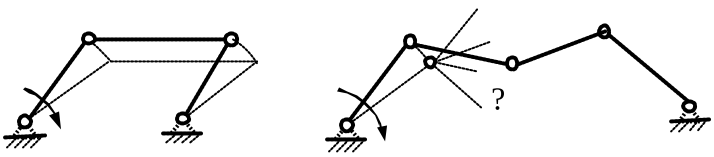


Figura 1.5

$$M = L - 6 = 6 \cdot (n-1) - \sum_{k=1}^{5} k \cdot C_k = 6 \cdot m - \sum_{k=1}^{5} k \cdot C_k \qquad (1.2)$$

$$L = (6-3) \cdot n - (5-3) \cdot C_5 - (4-3) \cdot C_4 \qquad (1.3)$$

$$M = 3 \cdot m - 2 \cdot C_5 - C_4 \qquad (1.4)$$

$$M = (6-f) \cdot m - \sum_{k=1}^{5} (k-f) \cdot C_k \qquad (1.5)$$

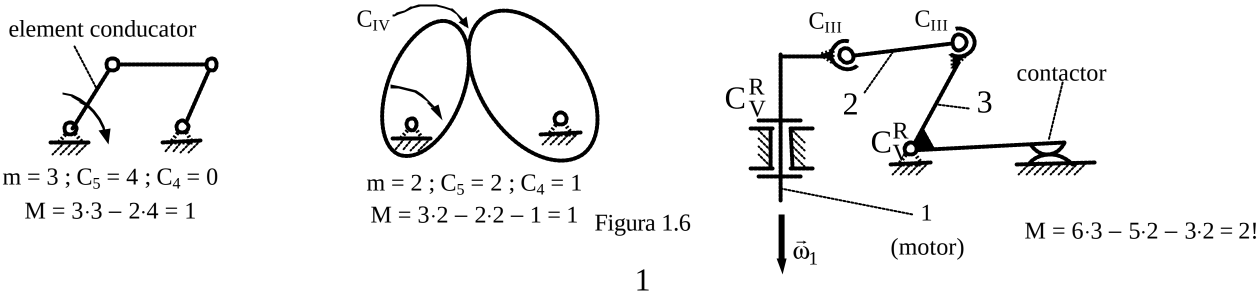
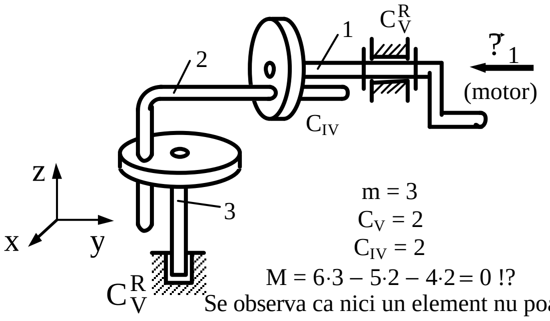


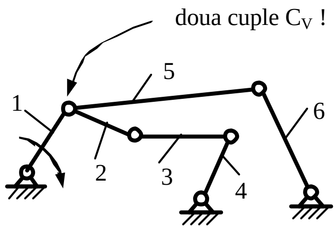
Figura 1.6

Mecanismul spatial schematizat în figura 1.7 are: m = 3, $C_5 = 2$, $C_4 = 2$ si f = 1. Ca urmare, aplicând relatia (1.5), rezulta M = 1.



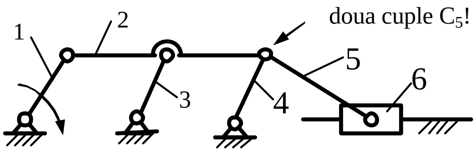
m = 3
$C_V = 2$
$C_{IV} = 2$
$M = 6 \cdot 3 - 5 \cdot 2 - 4 \cdot 2 = 0$!?
Se observa ca nici un element nu poate avea rotatie fata de (Oy).

Figura 1.7



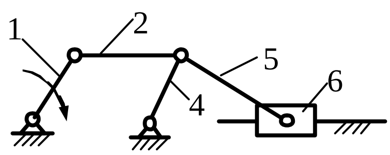
m = 6 ; $C_V = 7$!
$M = 3 \cdot 6 - 2 \cdot 7 = 4$

Figura 1.8



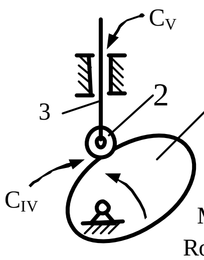
m = 6 ; $C_5 = 9$
$M = 3 \cdot 6 - 2 \cdot 9 = 0$?!
Elementul 3 este pasiv! Ajuta la rigidzarea barei 2.

Figura 1.9.a



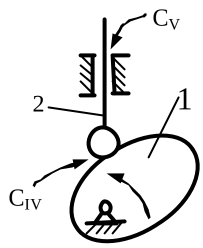
m = 5 ; $C_5 = 7$
$M = 3 \cdot 5 - 2 \cdot 7 = 1$

Figura 1.9.b



m = 3
$C_5 = 3$
$C_4 = 1$
$M = 3 \cdot 3 - 2 \cdot 3 - 1 = 2$!?
Rola 2 poate fi îndepartata.

Figura 10.a



m = 2
$C_5 = 2$
$C_4 = 1$
$M = 3 \cdot 2 - 2 \cdot 2 - 1 = 1$

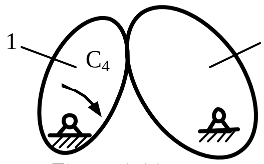
Figura 10.b

$$3 \cdot m_{ech} - 2 \cdot C_{5\,ech} = -1 \tag{1.6}$$

$$C_{5ech} = \frac{3 \cdot m_{ech} + 1}{2} \tag{1.7}$$

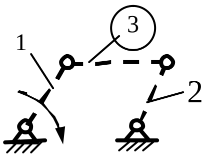
Tabelul 1.2

m_{ech}	1	3	5	7	….
$C_{5\,ech}$	2	5	8	11	….



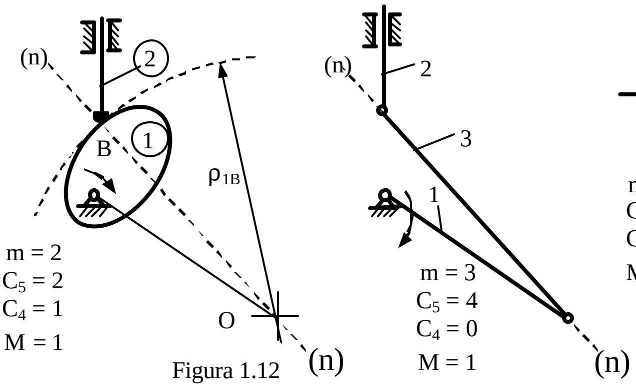
m = 2
$C_5 = 2$
$C_4 = 1$
M = 1

Figura 1.11.a



m = 2 + 1 = 3
$C_5 = 2 + 2 = 4$
$C_4 = 0$
M = 1

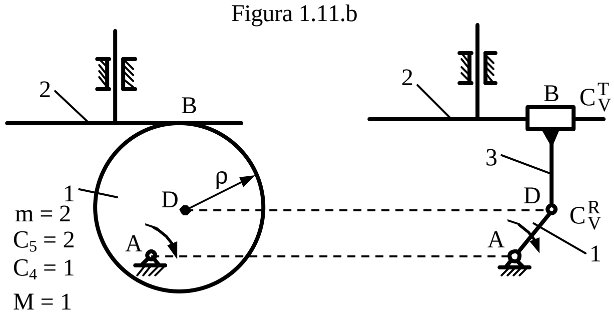
Figura 1.11.b



m = 2
$C_5 = 2$
$C_4 = 1$
M = 1

m = 3
$C_5 = 4$
$C_4 = 0$
M = 1

Figura 1.12



m = 2
$C_5 = 2$
$C_4 = 1$
M = 1

m = 3
$C_5 = 4$
$C_4 = 0$
M = 1

Figura 1.13

$$C_5 = \frac{3}{2} m \tag{1.8}$$

Tabelul 1.3

m	2	4	6	…
C_5	3	6	9	…

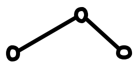


Figura 1.14 a

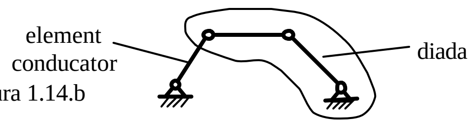


Figura 1.14.b

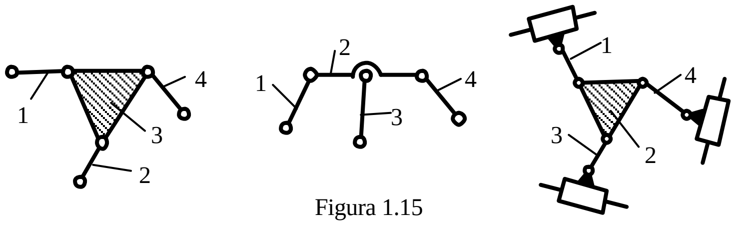


Figura 1.15

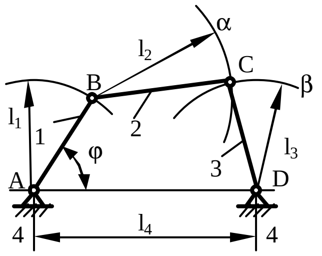


Figura 2.1

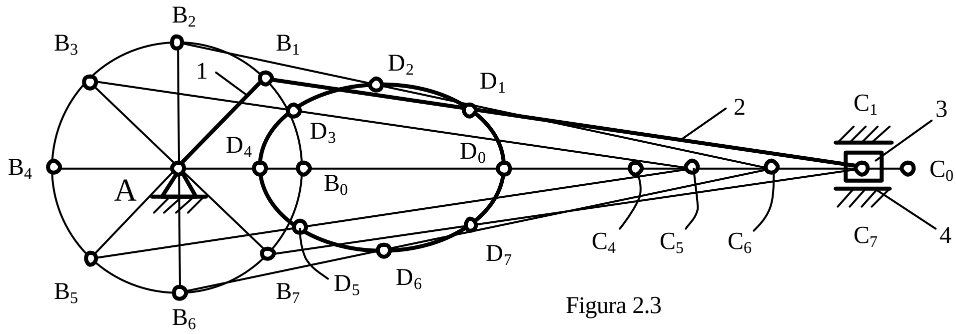


Figura 2.3

$$v_A = \omega \cdot l_{OA} \tag{2.1}$$

$$\frac{v_A}{l_{OA}} = \frac{K_v}{K_l} \cdot \frac{\overline{AV_A}}{\overline{OA}} \tag{2.2}$$

$$\omega = \frac{K_v}{K_l} \cdot tg\phi = K_\omega \cdot tg\varphi \tag{2.3}$$

$$K_\omega = 1 \quad \text{si deci} \quad \omega = tg\phi \tag{2.4}$$

$$a_A^n = \frac{v_A^2}{r_A} = \omega^2 \cdot r_A \tag{2.5}$$

$$a_A^t = \varepsilon \cdot r_A \tag{2.6}$$

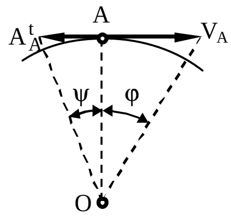


Figura 2.4

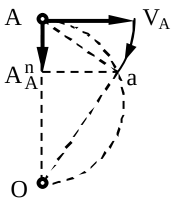


Figura 2.5

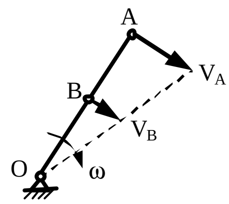


Figura 2.6

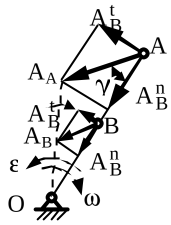


Figura 2.7

$$\varepsilon = \frac{a_A^t}{r_A} = \frac{K_a \cdot \overline{AA_A^t}}{K_l \cdot \overline{OA}} = \frac{K_A}{K_l} \cdot tg\psi \tag{2.7}$$

$$\varepsilon = K_\varepsilon \cdot tg\psi \tag{2.7'}$$

$$\varepsilon = tg\psi \tag{2.8}$$

$$\left(\overline{aA_A^n}\right)^2 = \overline{OA} \cdot \overline{AA_A^n}; \quad \overline{AA_A^n} = \frac{\left(\overline{AV_A}\right)^2}{\overline{OA}} = \frac{K_1}{K_v^2} \cdot \frac{v_A^2}{r_A} = \frac{K_l}{K_v^2} \cdot \bar{a}_A^n \tag{2.9}$$

sau $\bar{a}_A^n = \frac{K_v^2}{K_l} \cdot \overline{AA_A^n}$, adica vectorul $\overline{AA_A^n}$ reprezinta acceleratia $\bar{a}_A^n$ la scara K_a.

$$\bar{a}_A = \bar{a}_A^n + \bar{a}_A^t \tag{2.10}$$

$$a_A = \sqrt{\left(a_A^n\right)^2 + \left(a_A^t\right)^2} = \sqrt{\omega^4 \cdot l_{OA}^2 + \varepsilon^2 \cdot l_{OA}^2} = l_{OA} \cdot \sqrt{\omega^4 + \varepsilon^2} \tag{2.11}$$

$$a_B = l_{OB} \cdot \sqrt{\omega^4 + \varepsilon^2} \tag{2.12}$$

$$tg\gamma = \frac{a_A^t}{a_A^n} = \frac{r_A \cdot \varepsilon}{r_A \cdot \omega^2} = \frac{\varepsilon}{\omega^2} = \frac{a_B^t}{a_B^n} = \frac{r_B \cdot \varepsilon}{r_B \cdot \omega^2} = \frac{\varepsilon}{\omega^2} \tag{2.13}$$

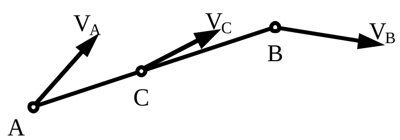


Figura 2.8

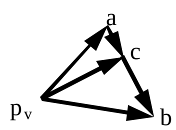


Figura 2.9

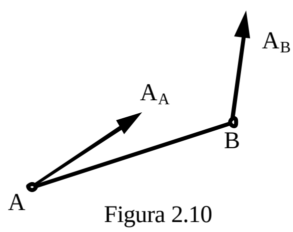


Figura 2.10

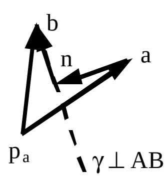


Figura 2.11

$$\bar{v}_B = \bar{v}_A + \bar{v}_{BA} \tag{2.14}$$

$$v_{BA} = \omega \cdot l_{AB}; \quad v_{BA} \perp AB \tag{2.15}$$

$$\bar{v}_C = \bar{v}_A + \bar{v}_{CA}, \text{ iar directia } \bar{v}_{CA} \perp AB. \tag{2.16}$$

$$\frac{ab}{ac} = \frac{AB}{AC} \tag{2.17}$$

$$\bar{a}_B = \bar{a}_A + \bar{a}_{BA} \tag{2.18}$$

$$\bar{a}_{BA} = \bar{a}^n_{BA} + \bar{a}^t_{BA} \tag{2.19}$$

$$\bar{a}_B = \bar{a}_A + \bar{a}^n_{BA} + \bar{a}^t_{BA} \tag{2.20}$$

$$a^n_{BA} = \frac{v^2_{BA}}{l_{BA}} = \omega^2 \cdot l_{AB}; \quad a^n_{BA} \parallel AB \tag{2.21}$$

$$a^t_{BA} = \varepsilon \cdot l_{AB}; \quad a^t_{BA} \perp AB \tag{2.22}$$

$$\begin{aligned} \bar{v}_A &= K_v \cdot \left(\overline{p_v a}\right) \\ v_B &= K_v \cdot \left(\overline{p_v b}\right) \\ \bar{v}_{BA} &= K_v \cdot \left(\overline{ab}\right) \end{aligned} \tag{2.23}$$

Pentru determinarea acceleratiilor se considera ecuatia vectoriala a acceleratiilor conform relatiei (2.18).

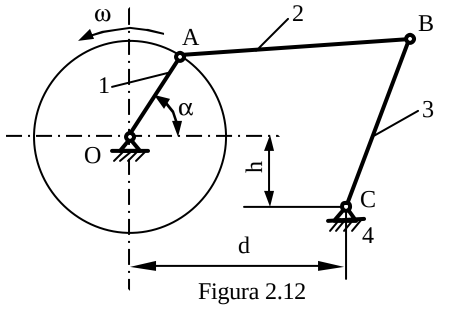


Figura 2.12

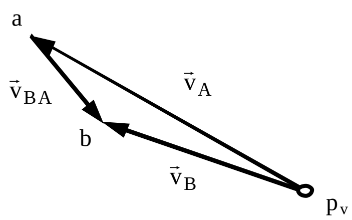


Figura 2.13

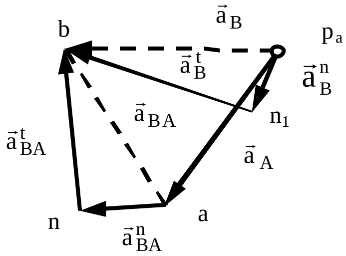


Figura 2.14

$$\bar{a}_B = \bar{a}^n_B + \bar{a}^t_B; \; \bar{a}_A = \bar{a}^n_A + \bar{a}^t_A; \; \bar{a}_{BA} = \bar{a}^n_{BA} + \bar{a}^t_{BA} \tag{2.24}$$

$$\bar{a}^n_B + \bar{a}^t_B = \bar{a}_A + \bar{a}^n_{BA} + \bar{a}^t_{BA} \tag{2.25}$$

$$\bar{a}^n_A = \frac{v^2_A}{l_1}; \quad \bar{a}^n_{BA} = \frac{v^2_{BA}}{l_2}; \quad \bar{a}^n_B = \frac{v^2_B}{l_3} \tag{2.26}$$

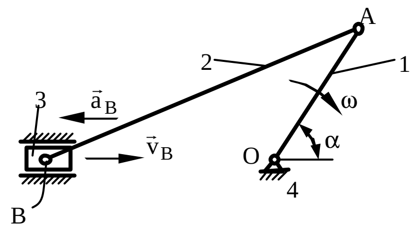


Figura 2.15

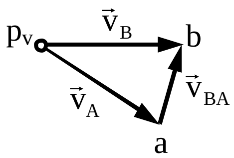


Figura 2.16

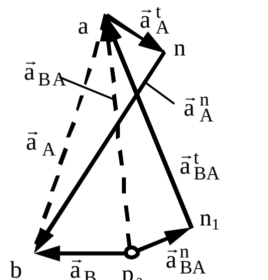


Figura 2.17

$$\bar{v}_{BA} = K_v \cdot \left(\overline{ab}\right); \; \bar{v}_A = K_v \cdot \left(\overline{p_v a}\right) \tag{2.27}$$

$$\bar{a}_B = \bar{a}^n_A + \bar{a}^t_A + \bar{a}^n_{BA} + \bar{a}^t_{BA} \tag{2.28}$$

$$\sum \bar{l}_n = 0 \tag{2.29}$$

$$\sum l_n \cdot e^{i \cdot \phi_n} = 0 \tag{2.30}$$

$$\sum \left(i \cdot l_n \cdot \omega_n \cdot e^{i \cdot \phi_n} + \dot{l}_n \cdot e^{i \cdot \phi_n} \right) = 0 \tag{2.31}$$

$$\sum \left(i \cdot \dot{l}_n \cdot \omega_n \cdot e^{i \cdot \phi_n} + i \cdot l_n \cdot \varepsilon_n \cdot e^{i \cdot \phi_n} - l_n \cdot \omega^2_n \cdot e^{i \cdot \phi_n} + \ddot{l}_n \cdot e^{i \cdot \phi_n} + i \cdot \dot{l}_n \cdot \omega_n \cdot e^{i \cdot \phi_n} \right) = 0 \tag{2.32}$$

$$\sum \left(i \cdot l_n \cdot \varepsilon_n \cdot e^{i \cdot \phi_n} - l_n \cdot \omega^2_n \cdot e^{i \cdot \phi_n} + 2 \cdot i \cdot \dot{l}_n \cdot \omega_n \cdot e^{i \cdot \phi_n} + \ddot{l}_n \cdot e^{i \cdot \phi_n} \right) = 0 \tag{2.33}$$

$$l_n \cdot e^{i \cdot \phi_n} = l_n \cdot \cos\phi_n + i \cdot l_n \cdot \sin\phi_n \tag{2.34}$$

$$\overline{O'O} + \overline{OA} + \overline{AB} = \overline{O'B} \quad \text{sau} \quad \bar{h} + \bar{l}_1 + \bar{l}_2 = \bar{x}_B \tag{2.35}$$

$$\begin{cases} \bar{l}_1 \cdot \cos\phi_1 + \bar{l}_2 \cdot \cos\phi_2 = \bar{x}_B \\ h + l_1 \cdot \sin\phi_1 + l_2 \cdot \sin\phi_2 = 0 \end{cases} \tag{2.36}$$

$$\sin\phi_2 = -\frac{l_1 \cdot \sin\phi_1 + h}{l_2} \tag{2.37}$$

$$\begin{cases} -l_1 \cdot \sin\phi_1 \cdot \dfrac{d\phi_1}{dt} - l_2 \cdot \sin\phi_2 \cdot \dfrac{d\phi_2}{dt} = \dfrac{dx_B}{dt} \\ l_1 \cdot \cos\phi_1 \cdot \dfrac{d\phi_1}{dt} + l_2 \cdot \cos\phi_2 \cdot \dfrac{d\phi_2}{dt} = 0 \end{cases} \tag{2.38}$$

$$\frac{d\phi_1}{dt}=\omega_1;\quad \frac{d\phi_2}{dt}=\omega_2;\quad \frac{dx_B}{dt}=\upsilon_B \tag{2.39}$$

$$\begin{cases} -l_1\cdot\omega_1\cdot\sin\phi_1 - l_2\cdot\omega_2\cdot\sin\phi_2=\upsilon_B \\ l_1\cdot\omega_1\cdot\cos\phi_1 + l_2\cdot\omega_2\cdot\cos\phi_2=0 \end{cases} \tag{2.40}$$

$$\omega_2=-\omega_1\cdot\frac{l_1\cdot\cos\phi_1}{l_2\cdot\cos\phi_2} \tag{2.41}$$

$$\begin{cases} -l_1\cdot\omega_1\cdot\cos\varphi_1\cdot\frac{d\varphi_1}{dt}-l_1\cdot\sin\varphi_1\cdot\frac{d\omega_1}{dt}-l_2\cdot\omega_2\cdot\cos\varphi_2\cdot\frac{d\varphi_2}{dt}-l_2\cdot\sin\varphi_2\cdot\frac{d\omega_2}{dt}=\frac{d\upsilon_B}{dt} \\ -l_1\cdot\omega_1\cdot\sin\varphi_1\cdot\frac{d\varphi_1}{dt}+l_1\cdot\cos\varphi_1\cdot\frac{d\omega_1}{dt}-l_2\cdot\omega_2\cdot\sin\varphi_2\cdot\frac{d\varphi_2}{dt}+l_2\cdot\cos\varphi_2\cdot\frac{d\omega_2}{dt}=0 \end{cases} \tag{2.42}$$

$$\begin{cases} -l_1\cdot\omega_1^2\cdot\cos\phi_1 - l_2\cdot\omega_2^2\cdot\cos\phi_2 - l_2\cdot\varepsilon_2\cdot\sin\phi_2=a_B \\ -l_1\cdot\omega_1^2\cdot\sin\phi_1 - l_2\cdot\omega_2^2\cdot\sin\phi_2 + l_2\cdot\varepsilon_2\cdot\cos\phi_2=0 \end{cases} \tag{2.43}$$

$$\varepsilon_2=\frac{l_1\cdot\omega_1^2\cdot\sin\phi_1 + l_2\cdot\omega_2^2\cdot\sin\phi_2}{l_2\cdot\cos\phi_2} \tag{2.44}$$

$$\sin\phi_2=-\frac{l_1}{l_2}\cdot\sin\phi_1 \tag{2.45}$$

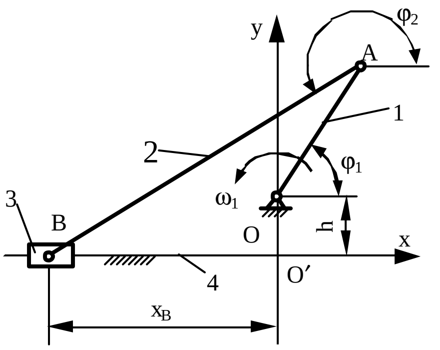


Figura 2.18

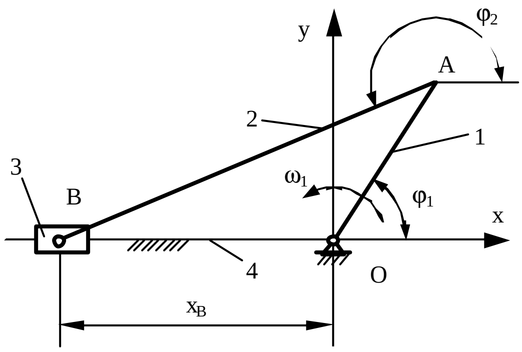


Figura 2.19

$$\tau_i=\begin{cases} \vec{F}_i=-m\cdot\vec{a}_G \\ \vec{M}_i=-J_G\cdot\vec{\varepsilon} \end{cases} \tag{3.1}$$

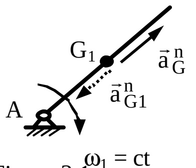


Figura 3.1.a

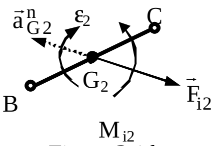


Figura 3.1.b

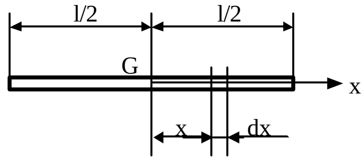


Figura 3.2

$$J_G=2\cdot\int_0^{l/2}x^2dm \tag{3.2}$$

$$J_G=2\cdot m'\cdot\int_0^{l/2}x^2dx=2\cdot m\cdot\frac{m'\cdot l^3}{12} \tag{3.3}$$

$$\tau_{i0}=\begin{cases} \vec{F}_i=\int_m d\vec{F}_i \\ \vec{M}_i=\int_m \vec{r}\times d\vec{F}_i \end{cases} \tag{3.4}$$

$$\vec{F}_i=\int_m d\vec{F}_i=-\int_m \vec{a}\cdot dm=-\int_m(-\omega^2\cdot\vec{\rho}+\vec{\varepsilon}\times\vec{\rho})\cdot dm \tag{3.5}$$

$$\vec{F}_i=\omega^2\cdot\int_m\vec{\rho}\cdot dm-\vec{\varepsilon}\times\int_m\vec{\rho}\cdot dm \tag{3.6}$$

$$\vec{M}_i=\int_m\vec{r}\times d\vec{F}_i=\int_m\left[(\vec{z}+\vec{\rho})\times\left(\omega^2\cdot\vec{\rho}-\vec{\varepsilon}\times\vec{\rho}\right)\right]\cdot dm \tag{3.7}$$

$$\vec{M}_i=\omega^2\cdot\int_m\vec{z}\times\vec{\rho}\cdot dm-\int_m\vec{z}\times\left(\vec{\varepsilon}\times\vec{\rho}\right)\cdot dm-\int_m\vec{\rho}\times\left(\vec{\varepsilon}\times\vec{\rho}\right)\cdot dm \tag{3.8}$$

$$\vec{M}_i=\vec{j}\cdot\omega^2\cdot\int_m z\cdot x\cdot dm-\vec{i}\cdot\omega^2\int_m y\cdot z\cdot dm+\vec{i}\cdot\varepsilon\cdot\int_m z\cdot x\cdot dm+\vec{j}\cdot\varepsilon\cdot\int_m y\cdot z\cdot dm-\vec{k}\cdot\varepsilon\cdot\int_m\rho^2\cdot dm \tag{3.9}$$

$$\vec{M}_i = \vec{i}\cdot(-\omega^2\cdot J_{yz}+\varepsilon\cdot J_{zx})+\vec{j}\cdot(\omega^2\cdot J_{zx}+\varepsilon\cdot J_{yz})-\vec{k}\cdot\varepsilon\cdot J_z \quad (3.10)$$

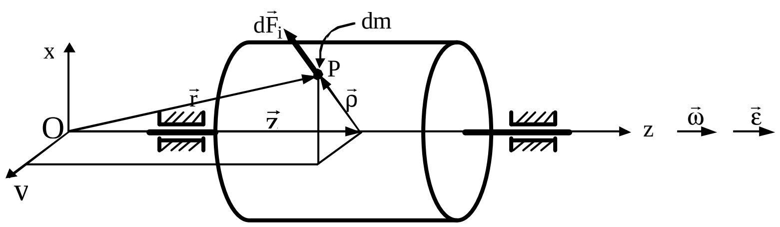


Figura 3.3

$$\vec{M}_i = \vec{i}\cdot M_{ix} + \vec{j}\cdot M_{iy} + \vec{k}\cdot M_{iz} \quad (3.11)$$

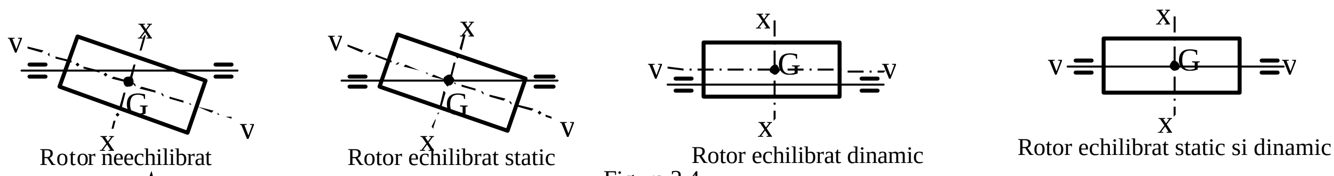


Figura 3.4

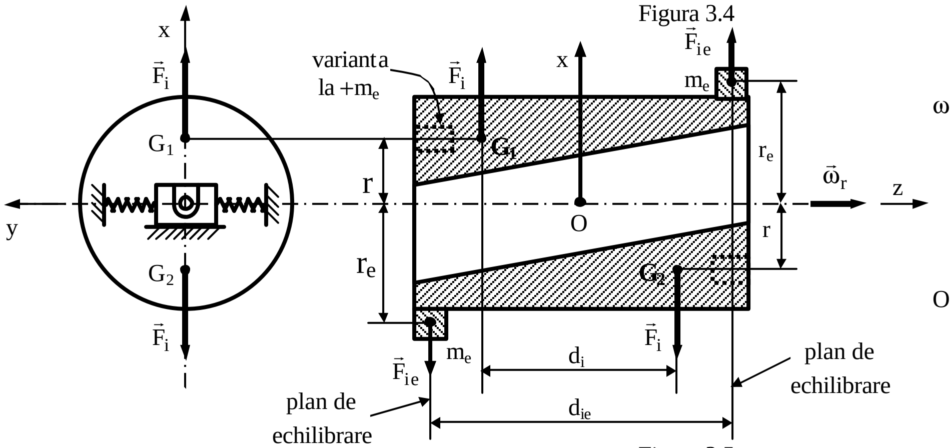


Figura 3.5

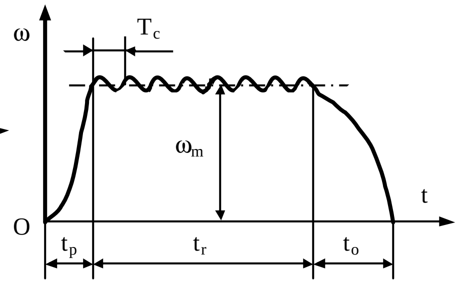


Figura 3.6

$$\sum\left(m_k\cdot\frac{v_{Gk2}^2}{2}-m_k\cdot\frac{v_{Gk1}^2}{2}\right)+\sum\left(J_k\cdot\frac{\omega_{k2}^2}{2}-J_k\cdot\frac{\omega_{k1}^2}{2}\right)=W_m-W_{ru}-W_{rp} \quad (3.12)$$

$$\sum m_k\cdot\frac{v_{Gk2}^2}{2}+\sum J_k\cdot\frac{{\omega_{k2}}^2}{2}=W_m-W_{ru}-W_{rp} \quad (3.13)$$

$$\sum m_k\cdot\frac{v_{Gk1}^2}{2}-\sum J_k\cdot\frac{\omega_{k1}^2}{2}=W_m-W_{ru}-W_{rp} \quad (3.14)$$

$$\eta=\frac{W_m-W_{rp}}{W_m}=1-\frac{W_{rp}}{W_m} \quad (3.15)$$

$$\eta=\frac{W_{ru}}{W_m}=\eta_1\cdot\eta_2\cdot\dots\cdot\eta_n=\prod\eta_i \quad (3.16)$$

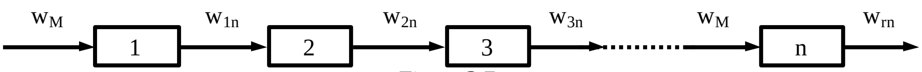


Figura 3.7

$$\sum\frac{m_k}{2}\cdot\left(v_{Gk2}^2-v_{Gk1}^2\right)+\sum\frac{J_k}{2}\cdot\left(\omega_{k2}^2-\omega_{k1}^2\right)=W_m-W_r \quad (3.17)$$

$$W_m=\sum\int_{l_{k1}}^{l_{k2}}F_{mk}\cdot\cos\alpha_k\cdot dl_k+\sum\int_{\varphi_{k1}}^{\varphi_{k2}}M_{mk}\cdot d\varphi_k \quad (3.18)$$

$$W_r=\sum\int_{l'_{k1}}^{l'_{k2}}F_{rk}\cdot\cos\alpha'_k\cdot dl'_k+\sum\int_{\varphi'_{k1}}^{\varphi'_{k2}}M_{rk}\cdot d\varphi'_k \quad (3.19)$$

(3.20)

$$F_{r.red.}\cdot dl=\sum F_{rk}\cdot\cos\alpha'_k\cdot dl'_k+\sum M_{mk}\cdot d\varphi'_k \quad (3.21)$$

$$F_{m.red.}=\sum F_{mk}\cdot\frac{v_k}{v'_B}\cdot\cos\alpha_k+\sum M_{mk}\cdot\frac{\omega_k}{v'_B} \quad (3.22)$$

$$F_{r.red.}=\sum F_{rk}\cdot\frac{v'_k}{v'_B}\cdot\cos\alpha'_k+\sum M_{rk}\cdot\frac{\omega'_k}{v'_B} \quad (3.23)$$

$$M_{m.red.} \cdot d\varphi = \sum F_{mk} \cdot \cos\alpha_k \cdot dl_k + \sum M_{mk} \cdot d\varphi_k \qquad (3.24)$$

$$M_{r.red.} \cdot d\varphi = \sum F_{rk} \cdot \cos\alpha'_k \, dl'_k + \sum M_{rk} \cdot d\varphi'_k \qquad (3.25)$$

$$M_{m.red.} = \sum F_{mk} \cdot \frac{v_k}{\omega} \cdot \cos\alpha_k + \sum M_{mk} \cdot \frac{\omega_k}{\omega} \qquad (3.26)$$

$$M_{m.red.} = \sum F_{rk} \cdot \frac{v'_k}{\omega} \cdot \cos\alpha'_k + \sum M_{rk} \cdot \frac{\omega'_k}{\omega} \qquad (3.27)$$

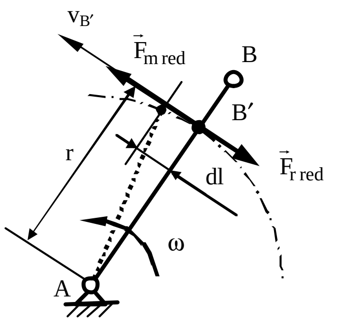


Figura 3.8

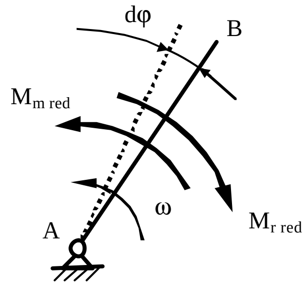


Figura 3.9

$$\frac{m_{red} \cdot v_{B'}^2}{2} = \sum \frac{m_k \cdot v_{Gk}^2}{2} + \sum \frac{J_k \cdot \omega_k^2}{2} \qquad (3.28)$$

$$m_{red} = \sum m_k \cdot \left(\frac{v_{Gk}}{v_{B'}}\right)^2 + \sum J_k \cdot \left(\frac{\omega_k}{v_{B'}}\right)^2 \qquad (3.29)$$

$$\frac{J_{red} \cdot \omega^2}{2} = \sum \frac{m_k \cdot v_{Gk}^2}{2} + \sum \frac{J_k \cdot \omega_k^2}{2} \qquad (3.30)$$

$$J_{red} = \sum m_k \cdot \left(\frac{v_{Gk}}{\omega}\right)^2 + \sum J_k \cdot \left(\frac{\omega_k}{\omega}\right)^2 \qquad (3.31)$$

$$\frac{m_{red2} \cdot v_{B'2}^2}{2} - \frac{m_{red1} \cdot v_{B'1}^2}{2} = \int_{l_1}^{l_2} \left(F_{m.red} - F_{r.red}\right) \cdot dl \qquad (3.32)$$

$$v_{B'2} = \sqrt{\frac{2}{m_{m.red}} \cdot \int_{l_1}^{l_2} F_{red} \cdot dl + \frac{m_{red1} \cdot v_{B'1}^2}{m_{red2}}} \qquad (3.33)$$

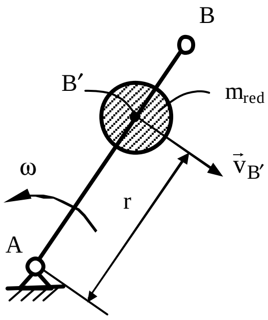


Figura 3.10

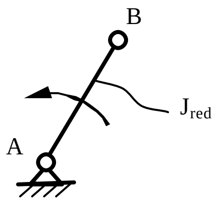


Figura 3.11

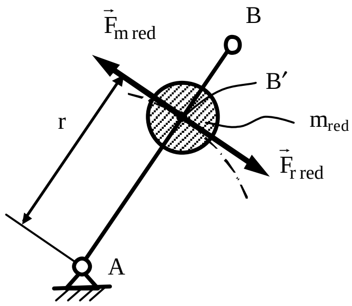


Figura 3.12

$$\omega_m = \frac{1}{\Delta\varphi} \cdot \int_{\varphi_1}^{\varphi_2} \omega \cdot d\varphi \qquad (4.1)$$

Se defineste gradul de neregularitate al mersului masinii (δ) ca fiind $\delta = \frac{\delta_{max} - \delta_{min}}{\delta_m}$ .Uzual, gradul de neregularitate al mersului masinii are valorile: $\delta = 1/5 \ldots 1/30$ - pentru pompe; $\delta = 1/20 \ldots 1/5$ – pentru concasoare; $\delta = 1/50 \ldots 1/30$ – pentru masini-unelte; $\delta = 1/300 \ldots 1/200$ – pentru motoare electrice de curent alternativ si $\delta \leq 1/200$ pentru motoare de aviatie.

Ca urmare, rezulta relatiile: $\omega_{max} = \omega_m \cdot \left(1 + \frac{\delta}{2}\right) \omega_{max}$ si $\omega_{min} = \omega_m \cdot \left(1 - \frac{\delta}{2}\right)$.

$$W_m = \int_0^{2\pi} M_{m.red} \cdot d\varphi \qquad (4.2)$$

$$W_r = \int_0^{2\pi} M_{r.red} \cdot d\varphi \qquad (4.3)$$

$$J_{red.max} \cdot \frac{\omega_{max}^2}{2} - J_{red.min} \cdot \frac{\omega_{min}^2}{2} = |\Delta W_{max}| \quad (4.4)$$

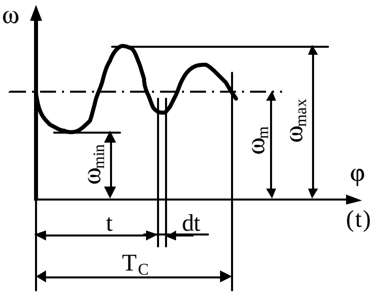


Figura 4.1

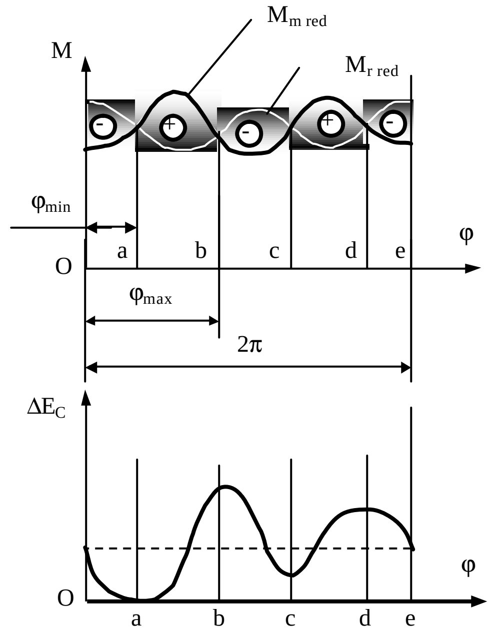


Figura 4.2

$$|\Delta W_{max}| = J_{red} \cdot \left(\frac{\omega_{max}^2}{2} - \frac{\omega_{min}^2}{2} \right) = J_{red} \cdot \omega_m^2 \cdot \delta \quad (4.5)$$

$$J_{red} = \frac{|\Delta W_{max}|}{\omega_m^2 \cdot \delta} \quad (4.6)$$

$$J_{total} = J = J_{red} + J_V \quad (4.7)$$

$$J_V = \frac{|\Delta W_{max}|}{\omega_m^2 \cdot \delta} - J_{red} \quad (4.8)$$

$$J_V \cong \frac{|\Delta W_{max}|}{\omega_m^2 \cdot \delta} \quad (4.9)$$

$$J = \frac{G \cdot D^2}{8 \cdot g} \quad (4.10)$$

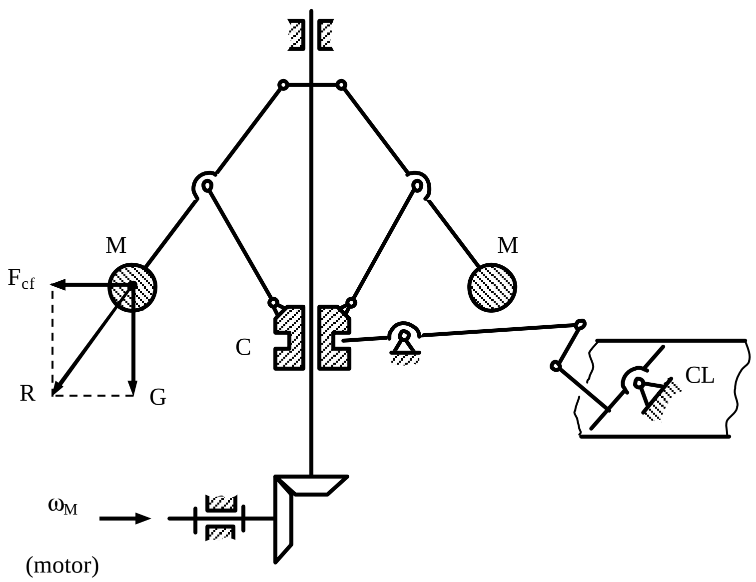


Figura 4.3

$$\phi = \mathrm{arctg}\frac{F_{f21}}{N_{21}} \tag{5.1}$$

$$p_m = \frac{N_{21}}{A_c} \le p_a \tag{5.2}$$

$$\begin{cases} N = P \cdot \cos\beta + Q \cdot \cos\alpha \\ \mu \cdot N + Q \cdot \sin\alpha = P \cdot \sin\beta \end{cases} \tag{5.3}$$

$$P = P_{max} = Q \cdot \frac{\sin(\alpha+\phi)}{\sin(\beta-\phi)} \tag{5.4}$$

$$P = P_{min} = Q \cdot \frac{\sin(\alpha-\phi)}{\sin(\beta+\phi)} \tag{5.5}$$

$$\begin{cases} 2 \cdot \mu \cdot N \ge P \\ \mu \cdot N \cdot a + N \cdot l = P \cdot \left(d + \frac{a}{2}\right) \end{cases} \tag{5.6}$$

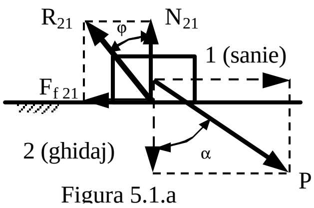


Figura 5.1.a

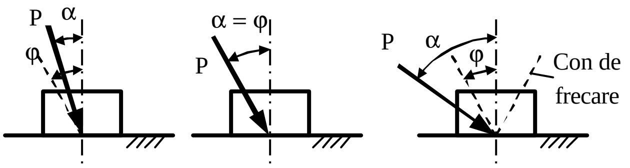


Figura 5.1.b

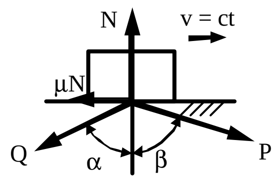


Figura 5.1.c

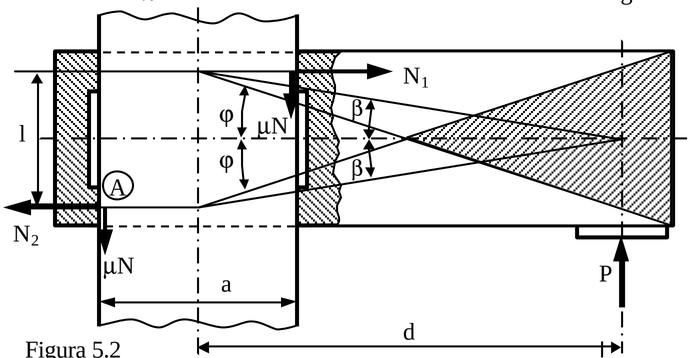


Figura 5.2

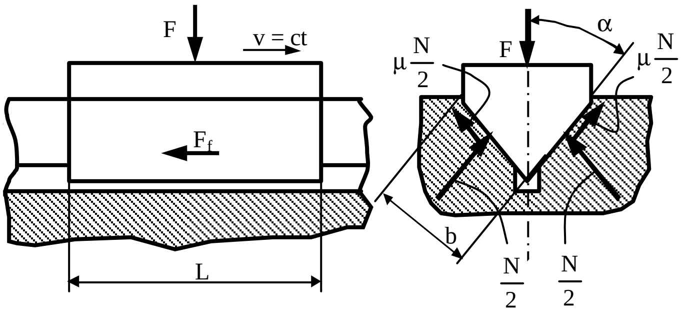


Figura 5.3

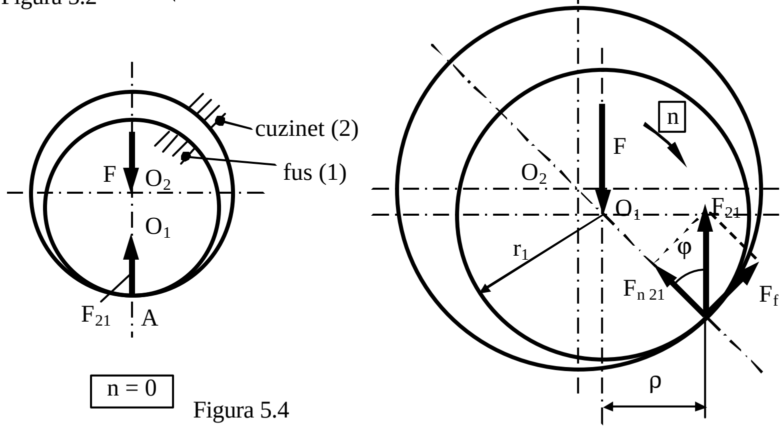


Figura 5.4

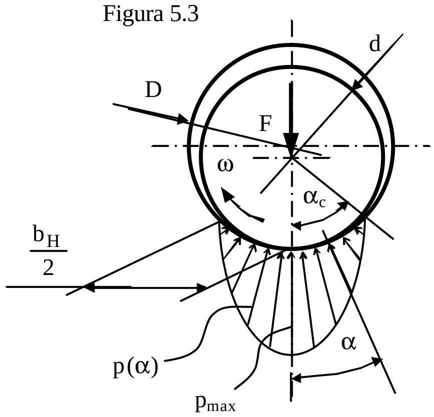


Figura 5.5

$$N = P \cdot \frac{2 \cdot d + a}{2 \cdot (l + \mu \cdot a)} \tag{5.7}$$

$$N = \frac{P}{2 \cdot \mu} \tag{5.8}$$

$$\mu \ge \frac{l}{2 \cdot d} \tag{5.9}$$

$$F = 2 \cdot \left(\frac{N}{2} \cdot \sin\alpha + \mu \cdot \frac{N}{2} \cdot \cos\alpha\right) \tag{5.10}$$

$$N = \frac{F}{\sin\alpha + \mu \cdot \cos\alpha} \tag{5.11}$$

$$p_m = \frac{N/2}{b \cdot L} \le p_a \tag{5.12}$$

$$F_f = \mu \cdot N = \frac{\mu}{\sin\alpha + \mu \cdot \cos\alpha} \cdot F = \mu_c \cdot F \tag{5.13}$$

$$\mu_c = \frac{\mu}{\sin\alpha + \mu\cos\alpha} \rangle \mu \text{ , } \mu_c \text{ este minim pentru } \alpha = \frac{\pi}{2} - \varphi . \quad (5.14)$$

$$\rho = r_1 \cdot \sin\varphi \approx r_1 \cdot \mathrm{tg}\,\varphi = r_1 \cdot \mu = ct. \quad (5.15)$$

$$M_f = F_{f21} \cdot r_1 = F_{21} \cdot \sin\varphi \cdot r_1 \approx F \cdot \mathrm{tg}\,\varphi \cdot r_1 = F \cdot r_1 \cdot \mu \quad (5.16)$$

$$p(\alpha) = p_{max} \cdot \sqrt{1 - \left(\frac{\alpha}{\alpha_c}\right)^2} \quad (5.17)$$

$$\sin\alpha_c = \sqrt{\frac{4}{\pi} \cdot \left(\frac{1-\nu_1^2}{E_1} + \frac{1-\nu_2^2}{E_2}\right) \cdot \frac{2 \cdot F}{B \cdot (D-d)}} \quad (5.18)$$

$$M_f = \int_{-\alpha_c}^{\alpha_c} \left[\mu \cdot p(\alpha) \cdot B \cdot \frac{D}{2} \cdot d\alpha\right] \cdot \frac{D}{2} \quad (5.19)$$

$$M_f = \mu \cdot \frac{\alpha_c}{\sin\alpha_c} \cdot F \cdot \frac{D}{2} = \mu_{ech} \cdot F \cdot r \text{), coeficientul de frecare conventional (echivalent): } \mu_{ech} = \frac{\mu \cdot \alpha_c}{\sin\alpha_c} . \quad (5.20)$$

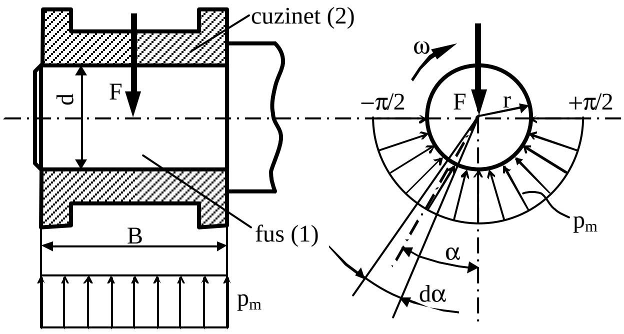


Figura 5.6

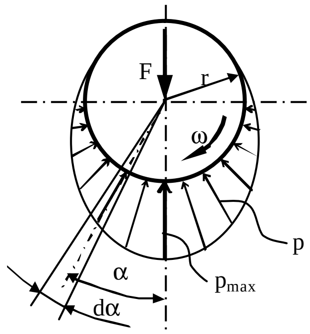


Figura 5.7

$$F = \int_{-\pi/2}^{\pi/2} p_m \cdot \left(\frac{d}{2} \cdot d\alpha\right) \cdot \cos\alpha \cdot B = p_m \cdot B \cdot d \quad (5.21)$$

$$p_m = \frac{F}{d \cdot B} \le p_a \quad (5.22)$$

$$M_f = \int_{-\pi/2}^{\pi/2} \mu \cdot p_m \cdot \left(\frac{d}{2} \cdot d\alpha\right) \cdot B \cdot \frac{d}{2} = \mu \cdot \pi \cdot p_m \cdot \frac{d^2}{4} \cdot B \quad (5.23)$$

$$M_f = \frac{\pi}{2} \cdot \mu \cdot p_m \cdot r^2 \cdot B \quad (5.24)$$

$$M_f = \frac{\pi}{2} \cdot \mu \cdot F \cdot r \cong 1{,}57 \cdot \mu \cdot F_r \quad (5.25)$$

$$F = 2 \cdot p_{max} \cdot \frac{d}{2} \cdot B \cdot \int_0^{\pi/2} \cos^2\alpha \cdot d\alpha \quad (5.26)$$

$$p_{max} = \frac{2 \cdot F}{\pi \cdot B \cdot r} \le p_a \quad (5.27)$$

$$p_{max} = \frac{4 \cdot F}{\pi \cdot B \cdot d} \le p_a \quad (5.28)$$

$$M_f = \frac{\mu \cdot B \cdot d^2 \cdot p_{max}}{2} \quad (5.29)$$

$$M_f = \frac{4}{\pi} \cdot \mu \cdot F \cdot r \text{ , } P = F_f \cdot v = \mu \cdot F \cdot v \quad (5.30)$$

$(p_m \cdot v) \le (p \cdot v)_{admisibil}$, respectiv $(p_{max} \cdot v) \le (p \cdot v)_{admisibil}$

$$p_m = \frac{4 \cdot F}{\pi \cdot (D_e^2 - D_i^2)} \le p_a \quad (5.31)$$

$$M_f = \int_{\frac{Di}{2}}^{\frac{De}{2}} (p_m \cdot 2\pi r \cdot dr) \cdot \mu \cdot r \quad (5.32)$$

$$M_f = \frac{1}{3} \cdot \mu \cdot F \cdot \frac{D_e^3 - D_i^3}{D_e^2 - D_i^2} \quad (5.33)$$

$$F=\int_{\frac{Di}{2}}^{\frac{De}{2}} p\cdot 2\pi r\cdot dr = 2\pi(pr)\cdot\int_{\frac{Di}{2}}^{\frac{De}{2}} dr \qquad (5.34)$$

$$F = 2\cdot\pi\cdot(p\cdot r)\cdot\frac{D_e-D_i}{2} \qquad (5.35)$$

$$p=\frac{F}{\pi\cdot(D_e-D_i)\cdot r}\text{, pentru } r = D_i/2,\ p_{max}=\frac{2\cdot F}{\pi\cdot(D_e-D_i)\cdot D_i}\ \text{ si pentru } r = D_e/2\ p_{min}=\frac{2\cdot F}{\pi\cdot(D_e-D_i)\cdot D_e} \qquad (5.36)$$

$$M_f = \int_{\frac{Di}{2}}^{\frac{De}{2}} (p\cdot 2\pi r\cdot dr)\cdot\mu\cdot r = 2\pi(pr)\cdot\mu\cdot\int_{\frac{Di}{2}}^{\frac{De}{2}} r\cdot dr \qquad (5.37)$$

$$M_f = 2\pi\mu\cdot(pr)\cdot\frac{D_e^2-D_i^2}{8}=\frac{\pi}{4}\cdot\mu\cdot(pr)\cdot\left(D_e^2-D_i^2\right) \qquad (5.38)$$

$$\text{Pentru } (p\cdot r)=\frac{F}{\pi\cdot(D_e-D_i)}:\ M_f=\frac{1}{4}\cdot\mu\cdot F\cdot(D_e+D_i) \qquad (5.39)$$

$(p_m\cdot v)\le(p\cdot v)_{admisibil}$, respectiv $(p_{max}\cdot v)\le(p\cdot v)_{admisibil}$ (5.40)

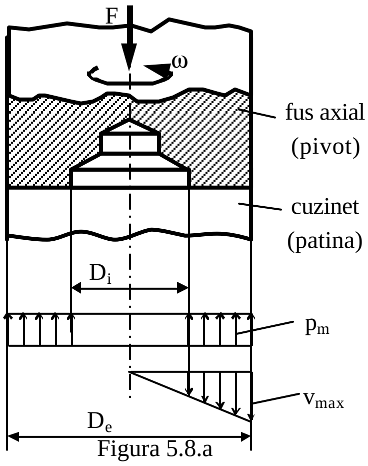


Figura 5.8.a

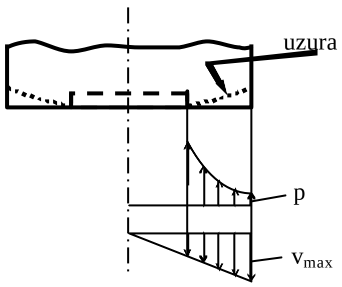


Figura 5.8.b

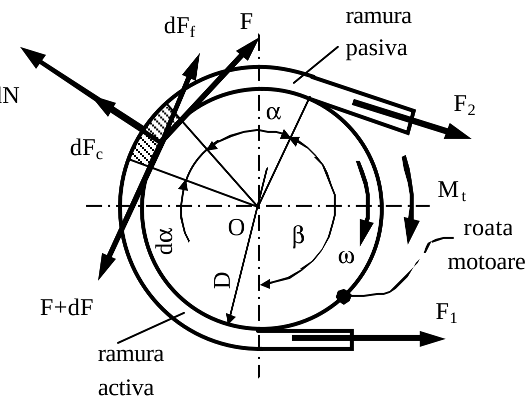


Figura 5.9

$$\begin{cases} dN + dF_c = (F+F+dF)\cdot\sin\frac{d\alpha}{2}\cong F\cdot d\alpha \\ dF_f = (F+dF-dF)\cdot\cos\frac{d\alpha}{2}\cong dF \end{cases}\quad \text{unde: } dF_f=\mu\cdot dN \text{ si } dF_c = r\cdot\omega^2\cdot dm = r\cdot\frac{v^2}{r^2}\cdot r\cdot d\alpha\cdot B\cdot\rho\cdot s, \qquad (5.41)$$

$$dF_f = B\cdot s\cdot\rho\cdot v^2\cdot d\alpha \qquad (5.42)$$

$$\frac{dF}{d\alpha}-\mu\cdot F = -\mu\cdot B\cdot s\cdot\rho\cdot v^2 \qquad (5.43)$$

$$F = C\cdot e^{\mu\cdot\alpha}+B\cdot s\cdot\rho\cdot v^2 \qquad (5.44)$$

$$\alpha = 0 \ \Rightarrow\ F = F_2 \ \Rightarrow\ C = F_2 - B\cdot s\cdot\rho\cdot v^2 \qquad (5.45)$$

$$F = \left(F_2 - B\cdot s\cdot\rho\cdot v^2\right)\cdot e^{\mu\cdot\beta}+B\cdot s\cdot\rho\cdot v^2 \qquad (5.46)$$

$$F_1 = \left(F_2 - B\cdot s\cdot\rho\cdot v^2\right)\cdot e^{\mu\cdot\beta}+B\cdot s\cdot\rho\cdot v^2 \qquad (5.47)$$

$$F_u = \frac{2\cdot M_t}{D} \qquad (5.48)$$

$$F_u = F_1 - F_2 \qquad (5.49)$$

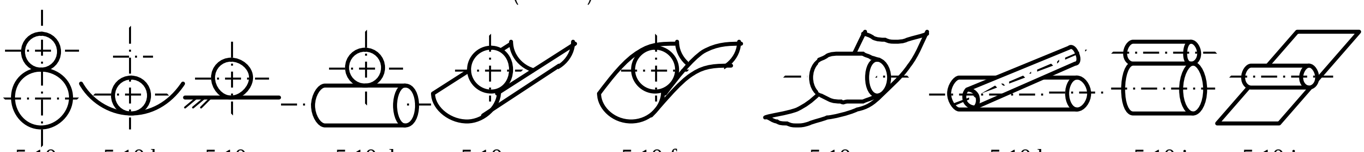
$$\begin{cases} F_1 = F_u\cdot\frac{e^{\mu\cdot\beta}}{e^{\mu\cdot\beta}-1}+B\cdot s\cdot\rho\cdot v^2 \\ F_2 = F_u\cdot\frac{1}{e^{\mu\cdot\beta}-1}+B\cdot s\cdot\rho\cdot v^2 \end{cases} \qquad (5.50)$$

$$F_1 = \frac{F_u}{e^{\mu\cdot\beta}-1}\cdot e^{\mu\cdot\beta}+B\cdot s\cdot\rho\cdot v^2 \qquad (5.51)$$

$$p=\sigma_s=\frac{dN}{dA}=\frac{F\cdot d\alpha - dF_c}{B\cdot\left(\frac{D}{2}\right)\cdot d\alpha}=\frac{2\cdot F_u}{B\cdot D\cdot\left(e^{\mu\cdot\beta}-1\right)}\cdot e^{\mu\cdot\beta} \qquad (5.52)$$

$$\text{Pentru } \alpha=\beta \ \Rightarrow\ p_{max}=\sigma_{smax}=\frac{2\cdot F_u\cdot e^{\mu\cdot\beta}}{B\cdot D\cdot\left(e^{\mu\cdot\beta}-1\right)} \qquad (5.53)$$

Pentru $\alpha = 0 \;\Rightarrow\; p_{max} = \sigma_{s\,max} = \dfrac{2\cdot F_u}{B\cdot D\cdot\left(e^{\mu\beta}-1\right)}$ (5.54)



5.10.a 5.10.b 5.10.c 5.10.d 5.10.e 5.10.f 5.10.g 5.10.h 5.10.i 5.10.j

$$F = \iint_S p_H\cdot dS = \int_{-b_H}^{b_H} p_H\cdot B\cdot db = \frac{\pi}{2}\cdot p_{H\,max}\cdot b_H\cdot B \quad (5.55)$$

$$p_{Hmax} = \sigma_{H\,max} = \frac{2\cdot F}{\pi\cdot b_H\cdot B} \quad (5.56)$$

$$b_H = \sqrt{\frac{4}{\pi}\cdot\frac{F\cdot\rho}{B}\cdot\left(\frac{1-\nu_1^2}{E_1}+\frac{1-\nu_2^2}{E_2}\right)} = \sqrt{\frac{8}{\pi}\cdot\frac{F\cdot\rho}{E_{ech}\cdot B}}\text{, unde } \frac{1}{\rho} = \frac{1}{\rho_1}+\frac{1}{\rho_2} \quad (5.57)$$

$$E_{ech} = \frac{2}{\dfrac{1-\nu_1^2}{E_1}+\dfrac{1-\nu_2^2}{E_2}} \quad (5.58)$$

$$\sigma_{H\,max} = \sqrt{\frac{F\cdot E_{ech}}{2\cdot\pi\cdot\rho\cdot B}} \quad (5.59)$$

În cazul particular cilindru/plan, $\rho_1 = R$, $\rho_2 \to \infty$, $E_1 = E$ si, ipotetic, $E_2 \to \infty$. Ca urmare, $E_{ech} = \dfrac{2}{2\cdot\dfrac{1-\nu^2}{E}}$

$$b_H = 1{,}076\cdot\sqrt{\frac{F\cdot R}{E\cdot B}} \quad (5.60)$$

$$\sigma_H = 0{,}418\cdot\sqrt{\frac{F\cdot E}{R\cdot B}} \quad (5.61)$$

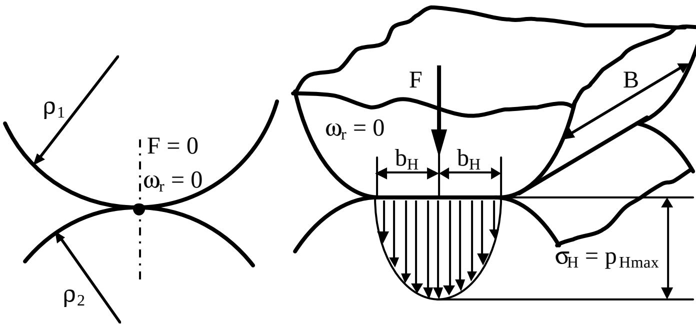


Figura 5.11

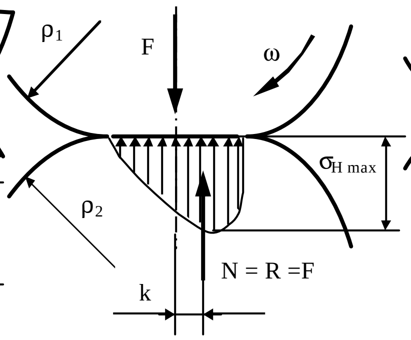


Figura 5.12

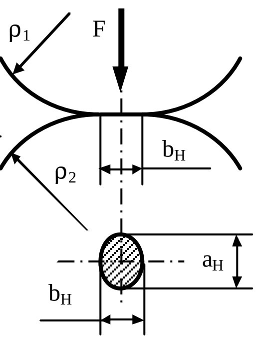


Figura 5.13

$$a_H = b_H = \sqrt[3]{\frac{3}{2}\cdot\frac{\eta\cdot F}{\sum k}}\text{ unde }\sum k = \frac{1}{\rho_1}+\frac{1}{\rho_2},\ \eta = \frac{1-\nu_1^2}{E_1}+\frac{1-\nu_2^2}{E_2} \quad (5.62)$$

$$\sigma_{H\,max} = \frac{1}{\pi}\cdot\sqrt[3]{\frac{3}{2}\cdot\left(\frac{\sum k}{\eta}\right)^2\cdot F} \quad (5.63)$$

$$P_{fi} = P_{fA}+P_{fB} = F_i\cdot k\cdot\omega_1\cdot\left(1+2\cdot\frac{\omega_b}{\omega_1}\right) \quad (5.64)$$

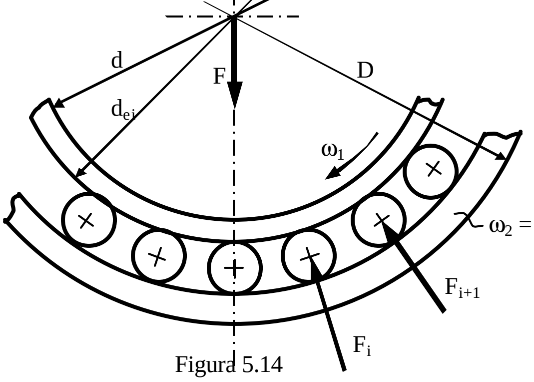


Figura 5.14

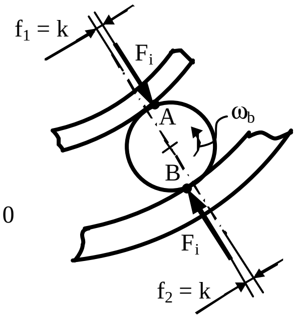


Figura 5.15

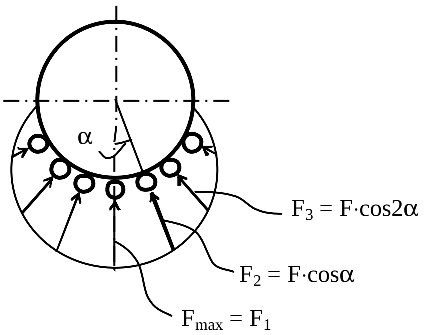


Figura 5,15

$$P_{fi} = F_i \cdot k \cdot \omega_1 \cdot \left(1 + 2 \cdot \frac{d_{ei}}{2 \cdot d_b}\right) = F_i \cdot k \cdot \omega_1 \cdot \left(1 + \frac{d_{ei}}{d_b}\right) \tag{5.65}$$

$$M_{fi} = \frac{P_{fi}}{\omega_1} = F_i \cdot k \cdot \left(1 + \frac{d_{ei}}{d_b}\right). \text{ Momentul de frecare total } M_f = \sum M_{fi} = k \cdot \left(1 + \frac{d_{ei}}{d_b}\right) \cdot \sum F_i \tag{5.66}$$

$$\sum F_i = \frac{4}{\pi} \cdot F \tag{5.67}$$

$$M_f = \frac{4}{\pi} \cdot k \cdot F \cdot \left(1 + \frac{d_{ei}}{d_b}\right) \tag{5.68}$$

$$M_f = \frac{4}{\pi} \cdot k \cdot F \cdot \frac{d}{2} \cdot \left(1 + \frac{d_{ei}}{d_b}\right) \cdot \frac{2}{d} \tag{5.69}$$

$$\mu_r = \frac{8}{\pi} \cdot \frac{k}{d} \cdot \left(1 + \frac{d_{ei}}{d_b}\right) << \mu_a \tag{5.70}$$

$$M_f = \mu_r \cdot F \cdot \frac{d}{2} \tag{5.71}$$

$$\begin{cases} P_{fi} = 2F_i \cdot k \cdot \omega_b \\ \omega_b \cdot d_b = \omega_1 \cdot \dfrac{d_m}{2} \end{cases} \tag{5.72}$$

$$P_{fi} = F_i \cdot k \cdot \omega_1 \cdot \frac{d_m}{d_b} \tag{5.73}$$

$$M_f = \frac{\sum P_{fi}}{\omega_1} = k \cdot \frac{d_m}{d_b} \cdot \sum F_i \tag{5.74}$$

$$M_f = k \cdot F \cdot \frac{d_m}{d_b} = \mu_r \cdot F \cdot \frac{d}{2} \tag{5.75}$$

$$\mu_r = \frac{2 \cdot k \cdot d_m}{d \cdot d_b} << \mu_a \tag{5.76}$$

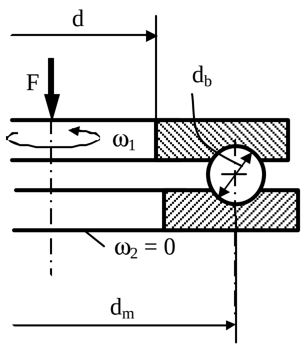


Figura 5.17

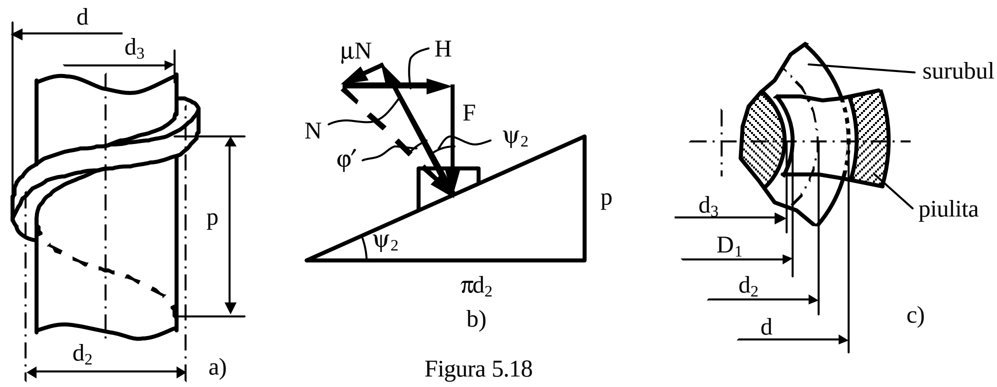
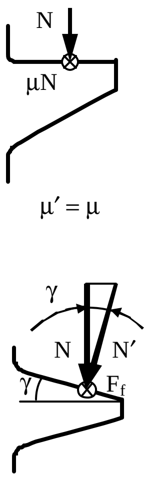
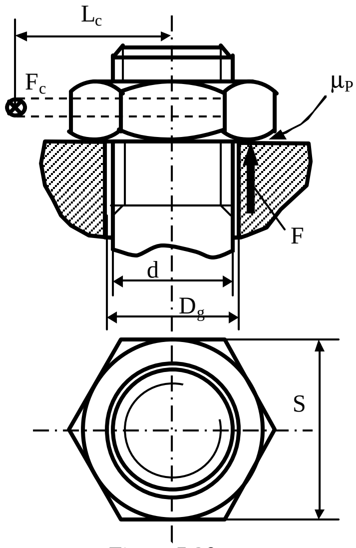


Figura 5.18





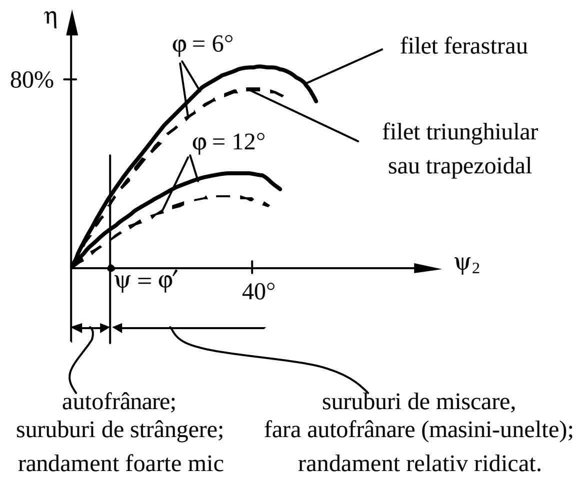


Figura 5.19 Figura 5.20 Figura 5.21

$$p_m = \frac{4 \cdot \frac{F}{z}}{\pi \cdot \left(d^2 - D_1^2\right)} \le p_a \tag{5.77}$$

$$H = F \cdot tg\left(\psi_2 + \phi'\right), \text{ unde } \psi_2 = arc\, tg \frac{p}{\pi \cdot d_2} \tag{5.78}$$

$$M_{t1} = H \cdot \frac{d_2}{2} = F \cdot \frac{d_2}{2} \cdot tg\left(\psi_2 + \phi'\right) \tag{5.79}$$

$$M'_{t1} = F \cdot \frac{d_2}{2} = F \cdot \frac{d_2}{2} \cdot tg\left(\psi_2 - \phi'\right) \tag{5.80}$$

Punând conditia ca $M'_{t1} \le 0$, rezulta conditia de autofrânare $\psi_2 \le \phi'$ (5.81)

$$M_2 = \frac{1}{3} \cdot \mu_p \cdot F \cdot \frac{S^3 - D_g^3}{S^2 - D_g^2} \tag{5.82}$$

$$M_{cheie} = F \cdot \frac{d_2}{2} \cdot tg\left(\psi_2 + \phi'\right) + \frac{1}{3} \cdot \mu_p \cdot F \cdot \frac{S^3 - D_g^3}{S^2 - D_g^2} \tag{5.83}$$

Pentru o cheie de lungime L_c rezulta forta la cheie $F_{cheie} = \frac{M_{cheie}}{L_c}$.

Pentru o lungime standardizata $L_c = \left(12 \cdots 15\right) \cdot d$, rezulta $F \cong \left(60 \cdots 100\right) \cdot F_{cheie}$!

$$\eta = \frac{L_u}{L_c} = \frac{F \cdot p}{H \cdot \pi \cdot d_2} = \frac{F \cdot tg\, \psi_2}{F \cdot tg\left(\psi_2 + \phi'\right)} = \frac{tg\, \psi_2}{tg\left(\psi_2 + \phi'\right)} \tag{5.84}$$

Punând conditia $\frac{d\eta}{d\psi} = 0$ pentru randamentul maxim $?_{max}$, rezulta $\psi_{opt} = \frac{\pi}{4} - \frac{\phi'}{2} \cong 41° \ldots 42°$.

$$\eta = \frac{tg\, \psi_2}{tg\, 2 \cdot \psi_2} = \frac{tg\, \psi_2}{\frac{2 \cdot tg\psi_2}{1 - tg^2\, \psi_2}} = \frac{1 - tg^2\, \psi_2}{2} \le 0{,}5 \; ! \tag{5.85}$$

$$\eta = \frac{M_{t1} \cdot 2 \cdot \pi}{\left(M_{t1} + M_2\right) \cdot 2 \cdot \pi} = \frac{F \cdot \frac{d_2}{2} \cdot tg\psi_2}{F \cdot \left[\frac{d_2}{2} \cdot tg\left(\psi_2 + \phi'\right) + \frac{1}{3} \cdot \mu_p \cdot \frac{S^3 - D_g^3}{S^2 - D_g^2}\right]} \text{ sau} \tag{5.86}$$

$$\eta = \frac{tg\psi_2}{tg\left(\psi_2 + \phi'\right) + \frac{2}{3} \cdot \mu_p \cdot \frac{S^3 - D_g^3}{d_2 \cdot \left(S^2 - D_g^2\right)}} \tag{5.87}$$

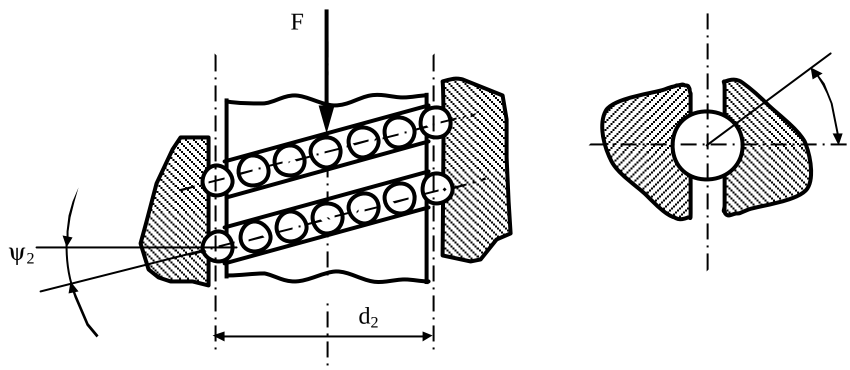


Figura 5.22

$$M_t = F \cdot \frac{d_2}{2} \cdot tg\left(\psi_2 + \phi_r\right) \tag{5.88}$$

Momentul este similar cu cel al cuplei surub–piulita cu alunecare, iar unghiul de frecare redus este $\phi_r = arc\, tg \frac{2 \cdot k}{d_2 \cdot \sin\gamma}$.

În acest caz randamentul atinge valori de 80…85%, iar puterea pierduta prin frecare este de 50…100 de ori mai mica decât în cazul suruburilor cu alunecare.