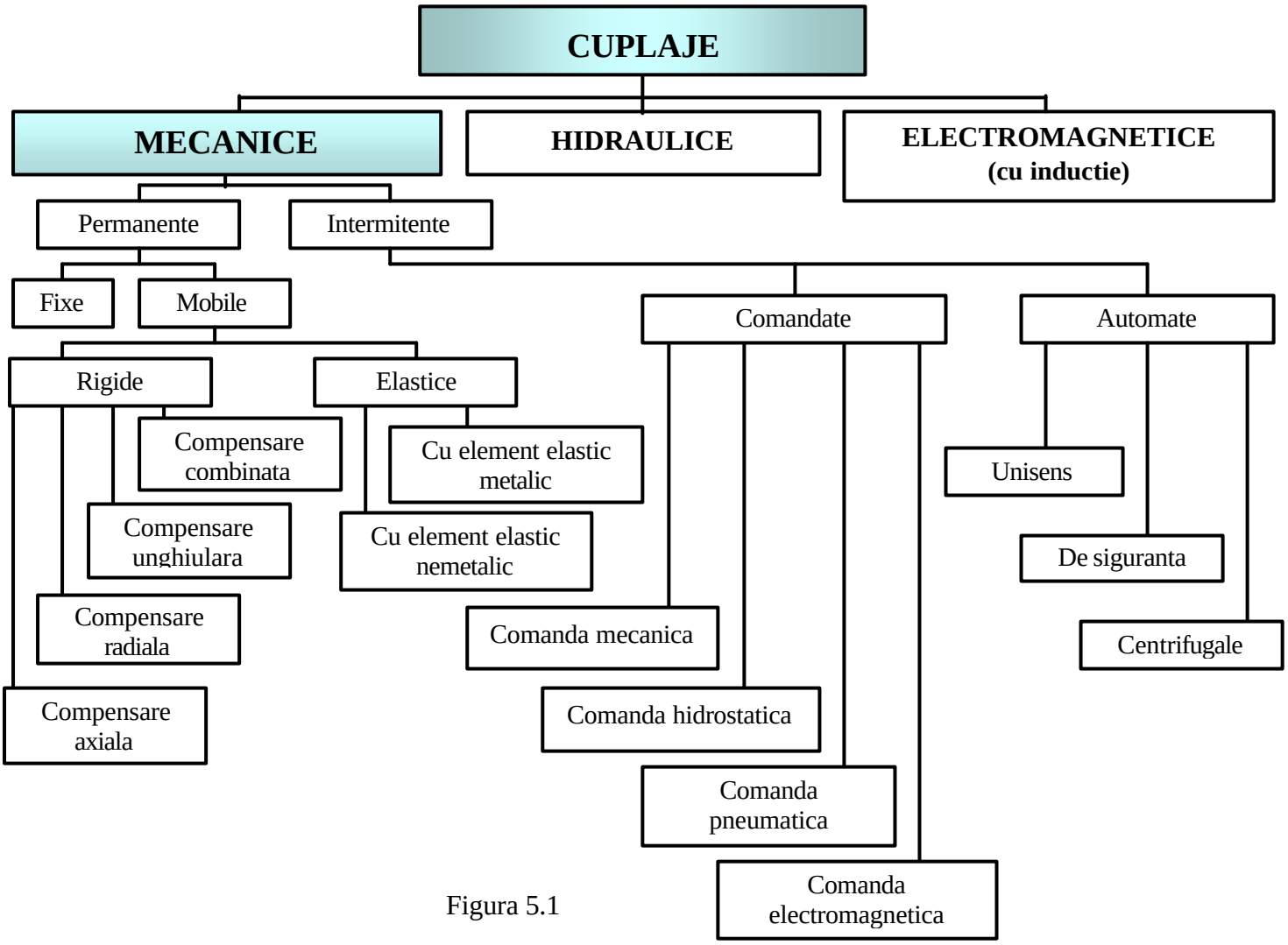


Figura 5.1

$$M_{t_{calcul}} = k_i \cdot k_s \cdot M_t \qquad (5.1)$$

Tabelul 5.1

Tipul masinii antrenate	**k_s**
Generatoare electrice	1 – 2
Ventilatoare	1,25 - 2
Pompe centrifuge si cu piston; compresoare cu piston	1,75 – 3,5
Masini-unelte	1,25 – 2,5
Masini-unelte pentru lemn; transportoare cu banda si cu lant	1,5 - 2
Transportoare cu role	4
Masini de ridicat; elevatoare	3 – 5

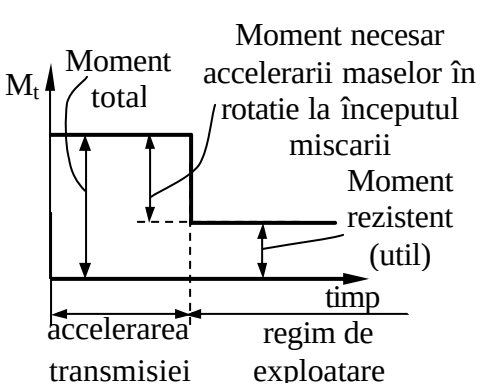


Figura 5.2.a

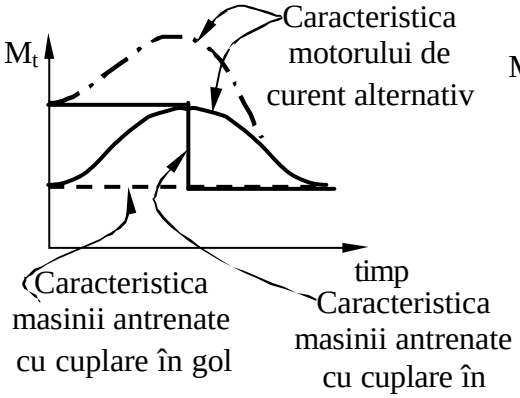


Figura 5.2.b

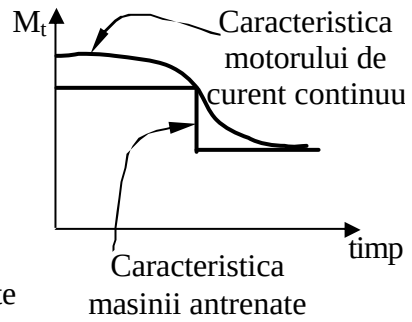


Figura 5.2.c

$$J_1 \cdot \omega_1 + J_2 \cdot \omega_2 - (J_1 + J_2) \cdot \omega_C = 0 \qquad (5.2)$$

$$\Delta E_c = \frac{J_1 \cdot \omega_1^2}{2} + \frac{J_2 \cdot \omega_2^2}{2} - \frac{(J_1 + J_2) \cdot \omega_C^2}{2} \qquad (5.3)$$

$$\omega_C = \frac{J_1 \cdot \omega_1 + J_2 \cdot \omega_2}{J_1 + J_2} \quad (5.4)$$

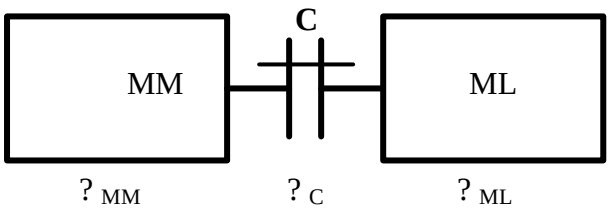


Figura 5.3.a

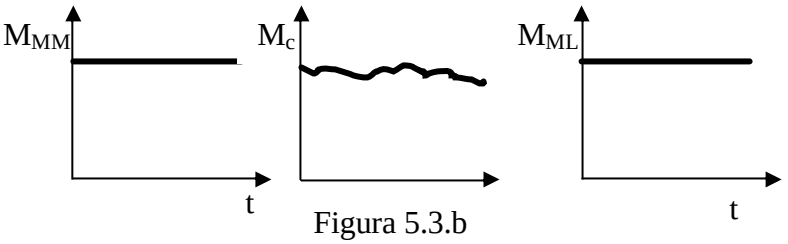


Figura 5.3.b

$$\Delta E_c = \frac{J_1 \cdot J_2}{2 \cdot (J_1 + J_2)} \cdot (\omega_1 - \omega_2)^2 = \frac{J_1 \cdot J_2}{2 \cdot (J_1 + J_2)} \cdot (\Delta\omega)^2 \quad (5.5)$$

$$\Delta E_c = \frac{1}{2} \cdot M_s \cdot \phi \quad (5.6)$$

$$M_s = c_t \cdot \phi \quad (5.7)$$

$$M_s = \sqrt{2} \cdot (\Delta\omega) \cdot \sqrt{c_t} \cdot \sqrt{\frac{J_1}{1 + \frac{J_1}{J_2}}} \quad (5.8)$$

Tabelul 5.2

Denumirea	**Figura**	**Caracteristici si elemente constructive**
Cuplaj cu manson monobloc	5.4 a	Momentul de torsiune se transmite prin intermediul stifturilor. Turatii acceptate: 200 ... 250 rot/min.Diametrele arborilor cuplati sunt cuprinse între 5 si 500 mm.
	5.4 b	Momentul de torsiune se transmite prin intermediul penelor sau canelurilor. Turatii acceptate: 200 ... 250 rot/min. Diametrele arborilor cuplati sunt între 5 si 500 mm.
	5.4 c	Momentul de torsiune se transmite prin frictiune, cu ajutorul strângerii exercitate de asamblarile pe con si prin pene paralele. Transmit momente de torsiune de 500 ... 1700 Nm. Diametrele arborilor cuplati sunt cuprinse între 10 si 70 mm.
	5.4 d	Momentul de torsiune se transmite prin frictiune, cu ajutorul strângerii exercitate de asamblarile pe con. Transmit momente de torsiune de 500 ... 1700 Nm. Diametrele arborilor cuplati sunt cuprinse între 10 si 70 mm.
	5.4 e	Momentul de torsiune se transmite prin frictiune, cu ajutorul strângerii exercitate de asamblarea pe con cu ulei sub presiune. Diametrele arborilor cuplati sunt cuprinse între 25 si 1000 mm.
Cuplaj cu manson din doua bucati	5.5	Asamblarea semimansoanelor se face cu suruburi, în vederea transmiterii momentului de torsiune prin frictiune. Pentru siguranta se utilizeaza si pene paralele. Pentru arbori verticali, penele paralele sunt prevazute cu ciocuri la ambele capete. Diametrele arborilor cuplati sunt cuprinse între 18 si 200 mm.

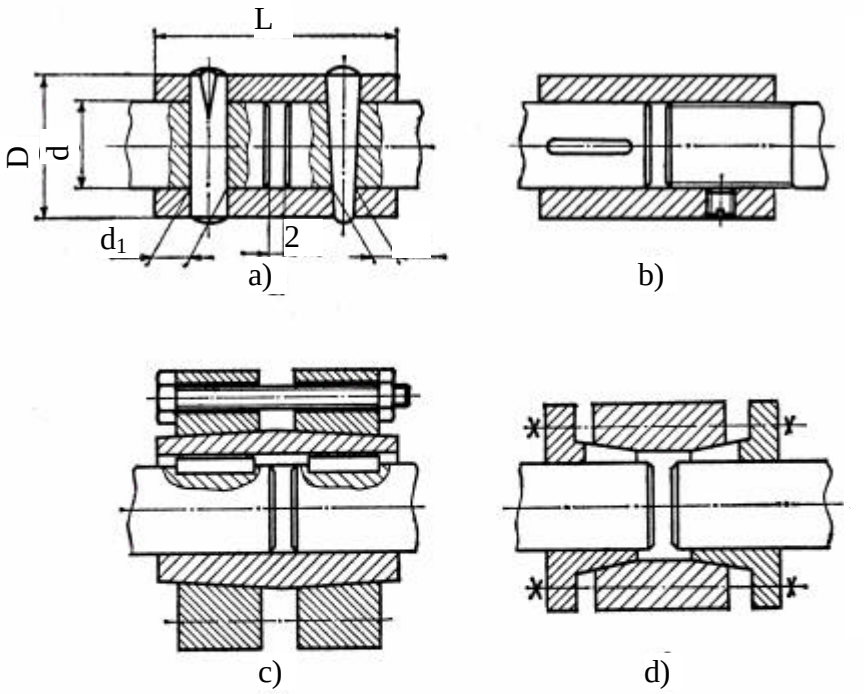
$$\tau_t = \frac{M_c}{\frac{\pi \cdot (D^4 - d^4)}{16 \cdot D}} \le \tau_{ta} \quad (5.9)$$

$$M_{t\,calcul} = M_t \cdot c_s \quad (5.10)$$

$$F_1 = \frac{2 \cdot M_{t\,calcul}}{D_1 \cdot n_s} \quad (5.11)$$

$$\sigma_s = \frac{F_1}{d_2 \cdot l_{c\,min}} \le \sigma_{s\,a} = 80...120 \text{ MPa} \quad (5.12)$$

$$\tau_f = \frac{4 \cdot F_1}{\pi \cdot d_2^2} \le \tau_{f\,a} = 50...80 \text{ MPa} \quad (5.13)$$



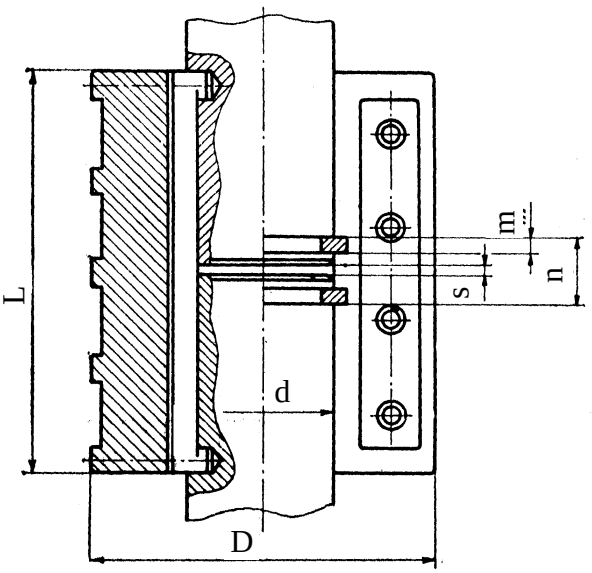


Figura 5.5

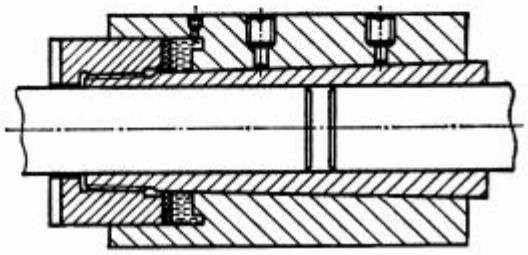


Figura 5.4

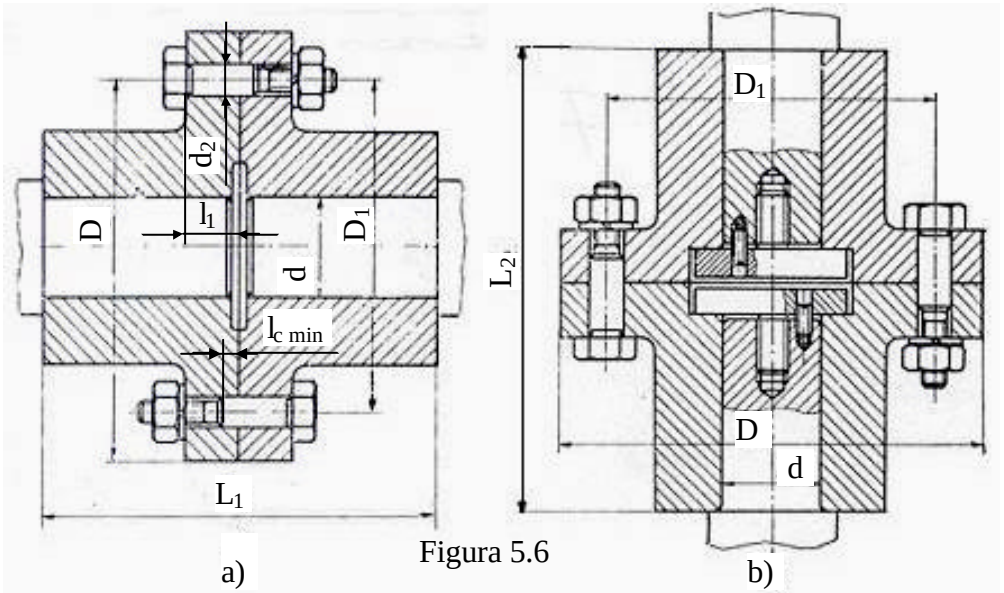


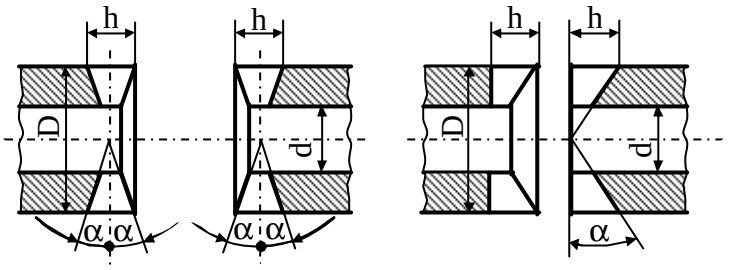
Figura 5.6

Tabelul 5.3

Diametrul arborelui - d	**Numarul de dinti - z**
d = 30 mm	12
30 ... 60 mm	24 sau 36
60 ... 120 mm	36 sau 48
d > 120 mm	72 sau 96

$$\sigma_i = \frac{6 \cdot M_{tc} \cdot h_m}{D_m \cdot z \cdot b \cdot a_m^2} \le \sigma_{ai} \qquad (5.14)$$

$$\sigma_s = \frac{2 \cdot M_{tc}}{D_m \cdot b \cdot z \cdot h_m} \le \sigma_{as} \qquad (5.15)$$



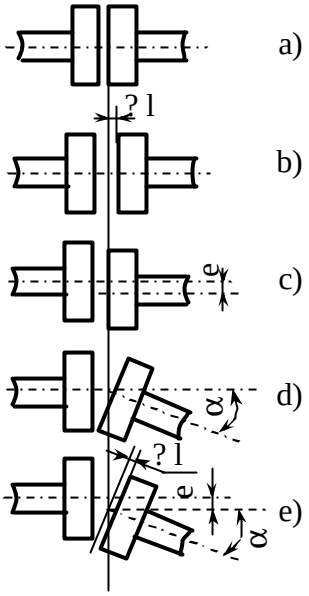


Figura 5.8

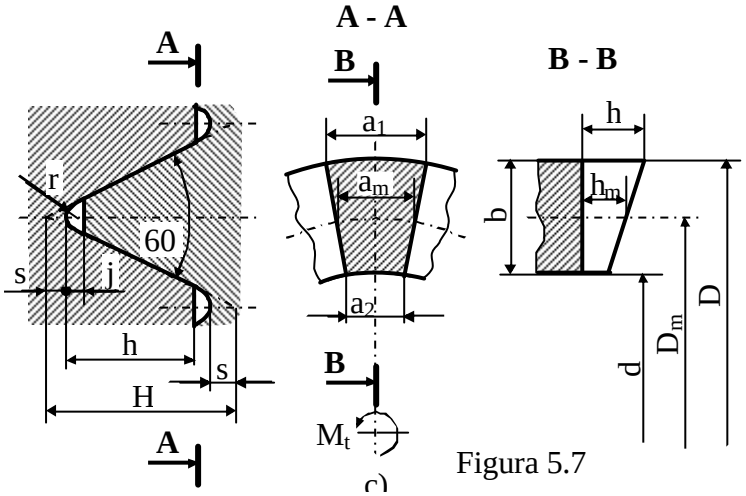


Figura 5.7

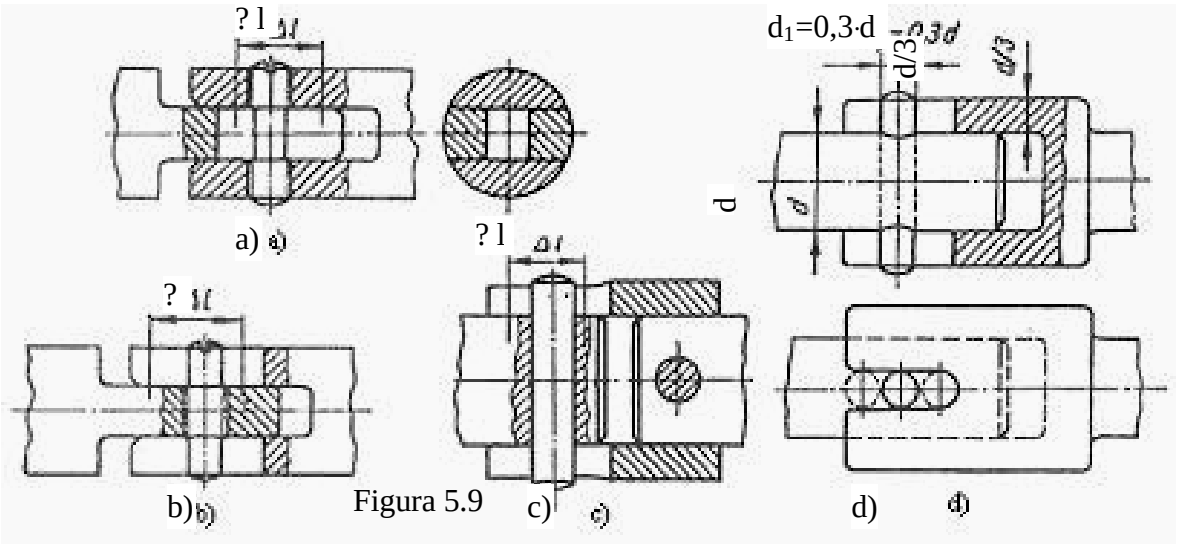


Figura 5.9

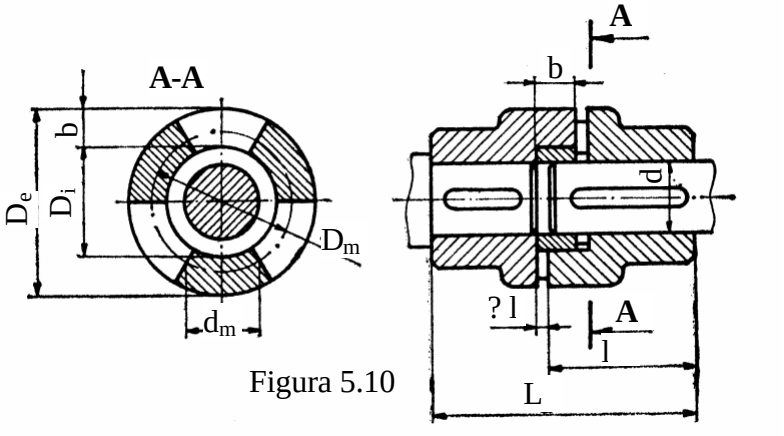


Figura 5.10

$$F_a = \frac{4 \cdot tg\alpha \cdot M_{tc}}{D_m} \qquad (5.16)$$

$$\sigma_i = \frac{6 \cdot M_{tc} \cdot h_m}{D_m \cdot z \cdot b \cdot a_m^2} \le \sigma_{ai} \qquad (5.17)$$

$$\sigma_s = \frac{2 \cdot M_{tc}}{D_m \cdot b \cdot z \cdot h_m} \le \sigma_{as} \qquad (5.18)$$

$$\eta = (1 \cdots 5{,}3) \cdot \mu \cdot e \cdot (D + d) \qquad (5.19)$$

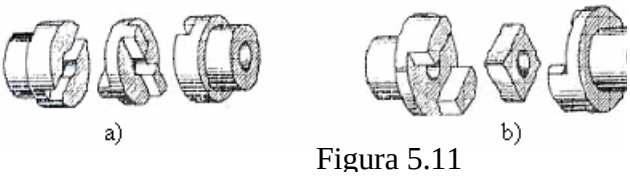


Figura 5.11

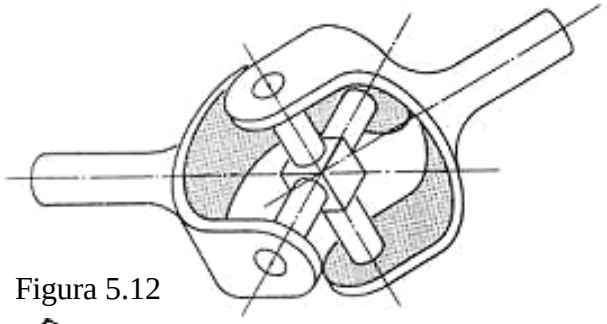


Figura 5.12

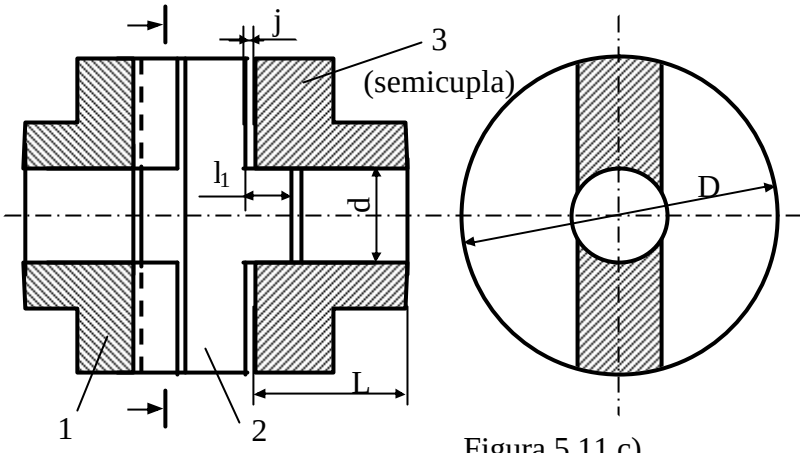


Figura 5.11.c)

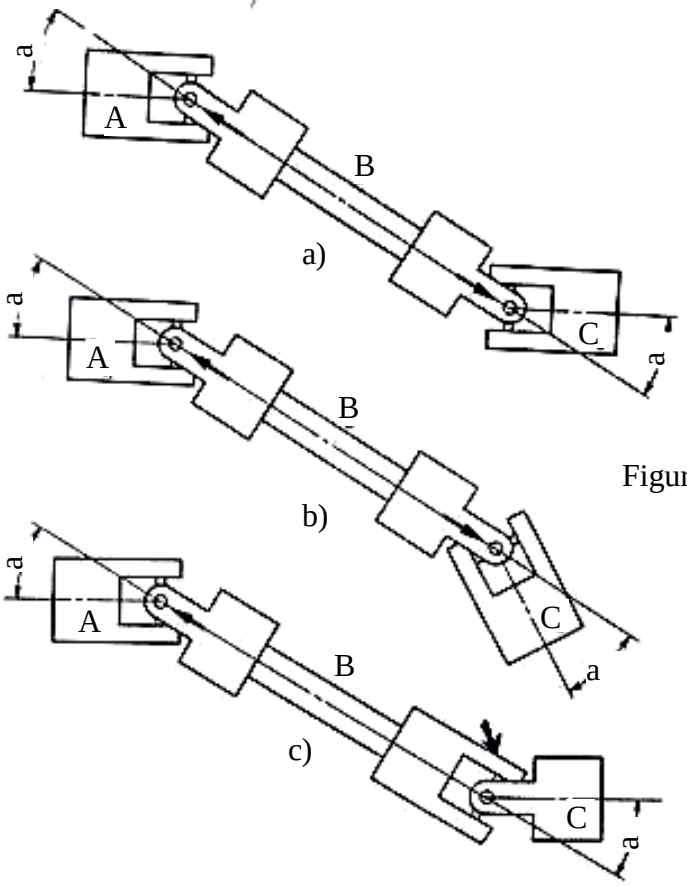


Figura 5.13

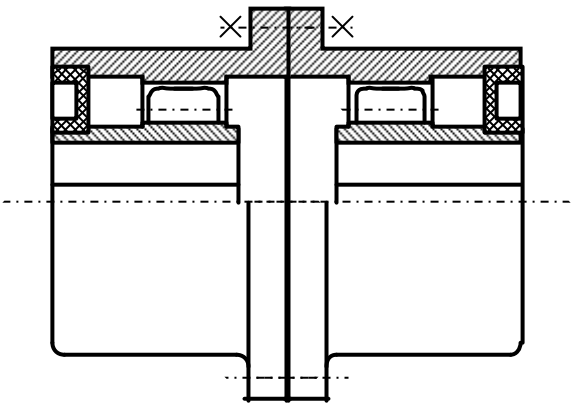


Figura 5.14

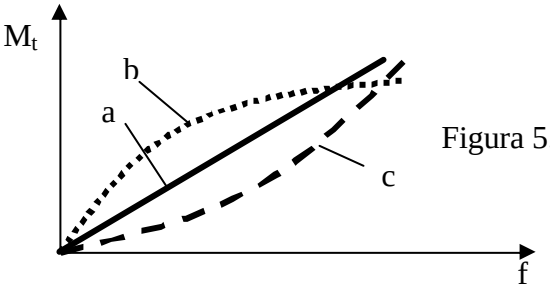


Figura 5.15

$$\sigma_s = \frac{12 \cdot M_t}{h \cdot (2 \cdot D + d - e) \cdot (D - d - 2e)} \le \sigma_{as} \qquad (5.20)$$

$$\omega_2 = \left(\frac{tg\phi_1 \cdot \sin\alpha}{\cos^2\alpha \cdot tg^2\phi_1} \cdot \frac{d\alpha}{dt} + \frac{\cos\alpha}{\cos^2\phi_1 \cdot \cos^2\alpha + \sin^2\phi_1} \right) \cdot \omega_1 \qquad (5.21)$$

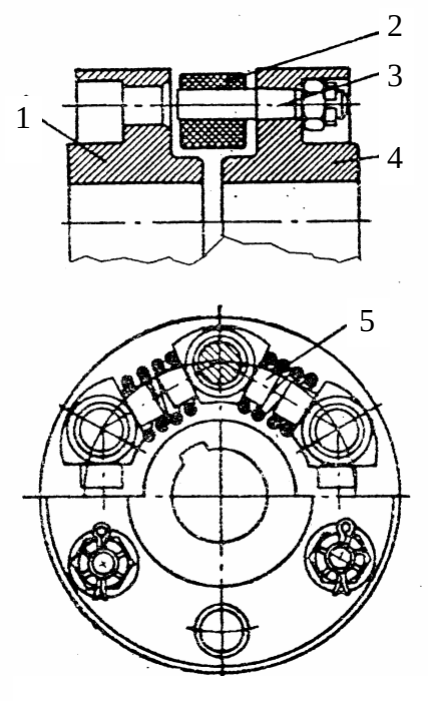
$$\omega_2 = \frac{\cos\alpha}{\cos^2\phi_1 \cdot \cos^2\alpha + \sin^2\phi_1} \cdot \omega_1 \qquad (5.22)$$

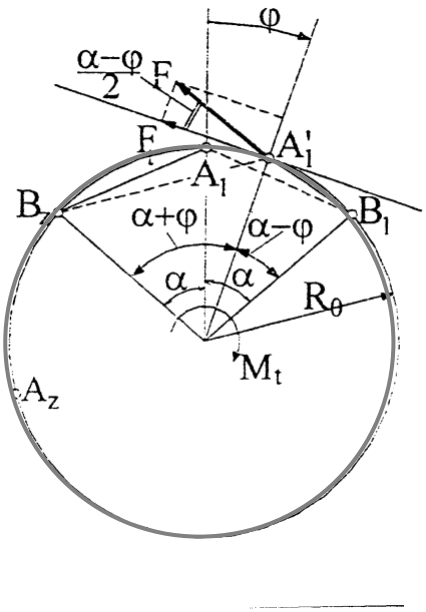
Pentru $f_1 = 0°$, $\omega_2 = \omega_{2max} = \frac{\omega_1}{\cos\alpha}$, iar pentru $f_1 = 90°$, $\omega_2 = \omega_{2min} = \omega_1 \cdot \cos\alpha$.

$$C = \frac{M_t}{\phi} \tag{5.23}$$

$$C = \frac{dM_t}{d\phi} \tag{5.24}$$

$$M_t = k \cdot \phi + \gamma \cdot \phi^3 \tag{5.25}$$





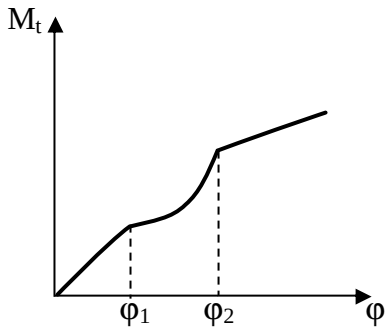
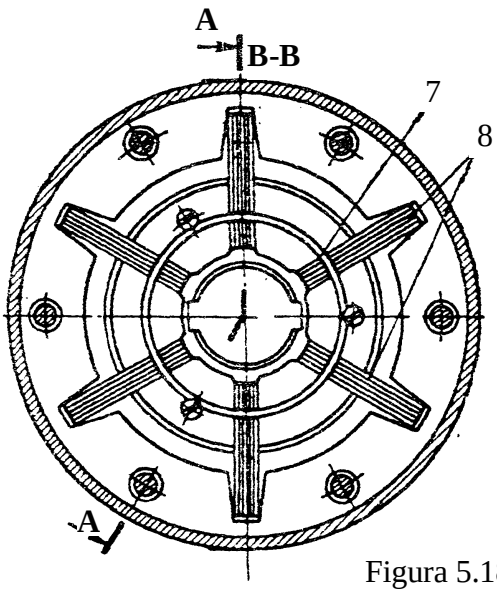


Figura 5.20



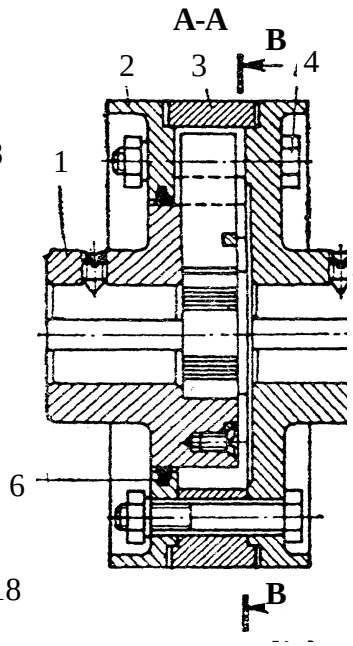


Figura 5.18

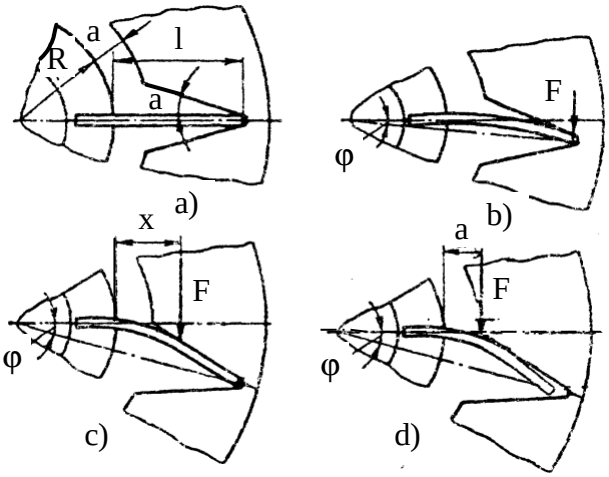


Figura 5.19

$$M_t = z \cdot F_t \cdot R_0 \tag{5.26}$$

$$F_t = \frac{F \cdot \cos(\alpha - \phi)}{2} \tag{5.27}$$

$$f = \frac{8D^3 nF}{Gd^4} \tag{5.28}$$

$$f = 2 \cdot R_0 \cdot \sin\frac{\phi}{2} - 2 \cdot R_0 \cdot \sin\frac{(\alpha - \phi)}{2} \tag{5.29}$$

$$M_t(\phi) = \frac{z \cdot G \cdot d^4 \cdot R_0^2}{4 \cdot D^3 \cdot n} \cdot (\sin\frac{\alpha}{2} - \sin\frac{\alpha - \phi}{2}) \cdot \cos\frac{\alpha - \phi}{2} \tag{5.30}$$

$$M(\phi) = \frac{3 \cdot E \cdot I \cdot (r + l)^2}{l^3} \cdot \phi \tag{5.31}$$

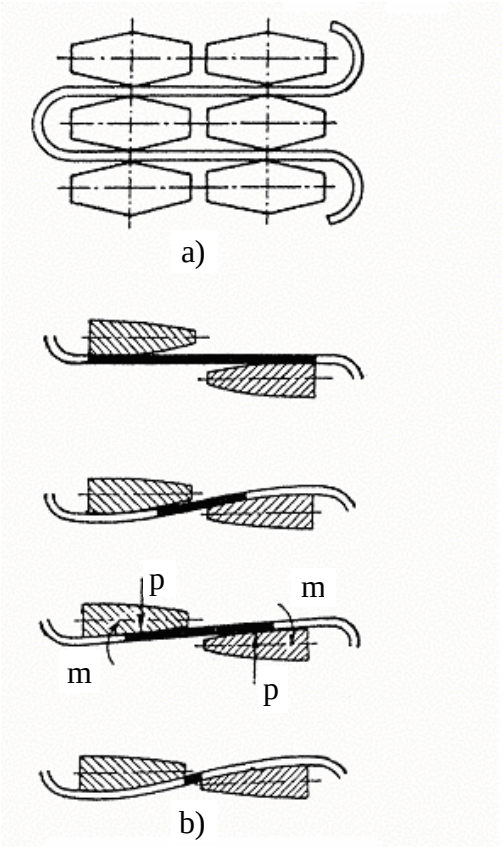


Figura 5.21

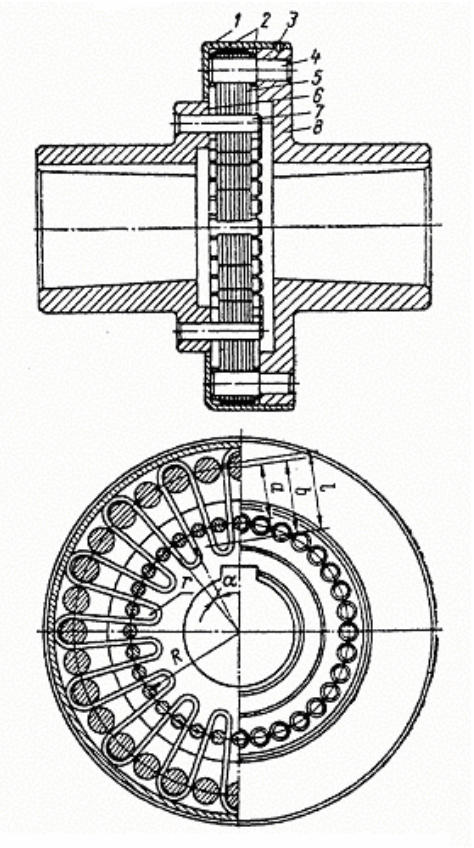


Figura 5.22

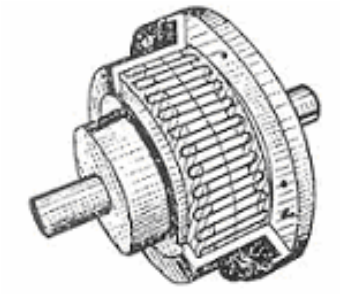


Figura 5.23

$$M_t = \frac{3 \cdot z \cdot E \cdot I \cdot D_0^2}{8 \cdot s^3} \cdot \phi \qquad (5.32)$$

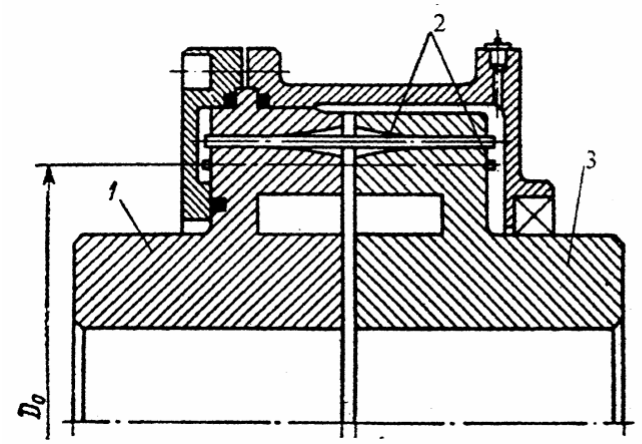


Figura 5.24

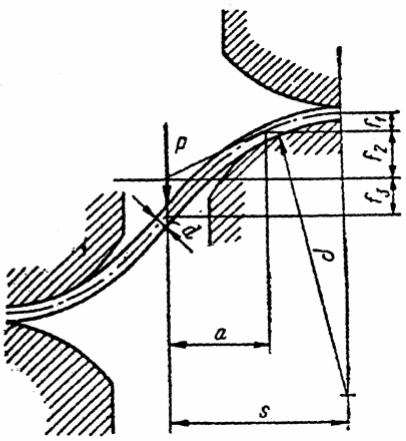
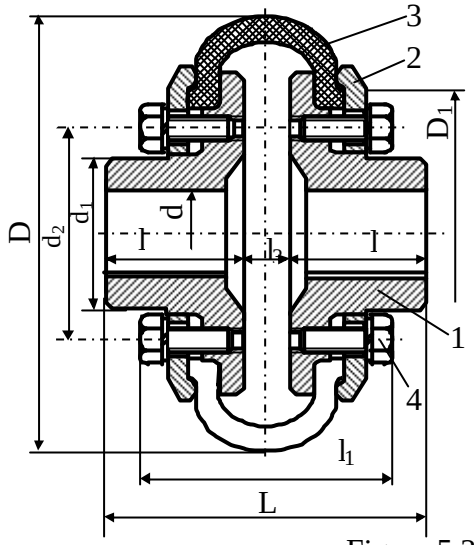


Figura 5.25

$$M_t = \frac{3 \cdot z \cdot E \cdot I \cdot D_0^2}{8 \cdot a^3} \cdot (\phi - \frac{2 \cdot (s^2 - a^2)}{\rho \cdot D_0}) \qquad (5.33)$$



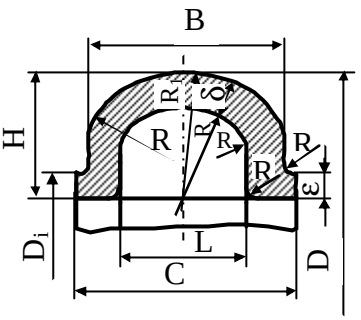


Figura 5.26

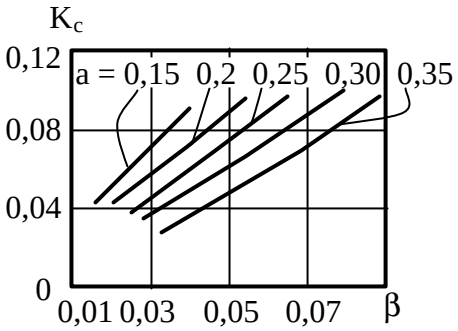


Figura 5.27

$$M_t(\phi) = K_c \cdot G \cdot D^3 \cdot \phi \qquad (5.34)$$

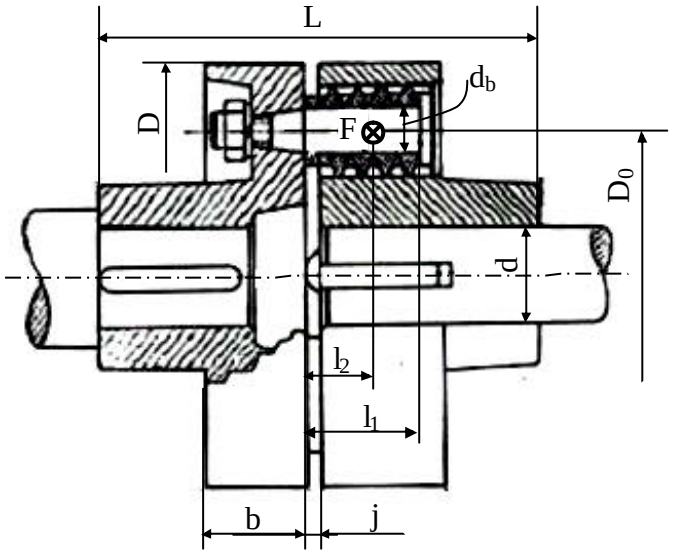


Figura 5.28

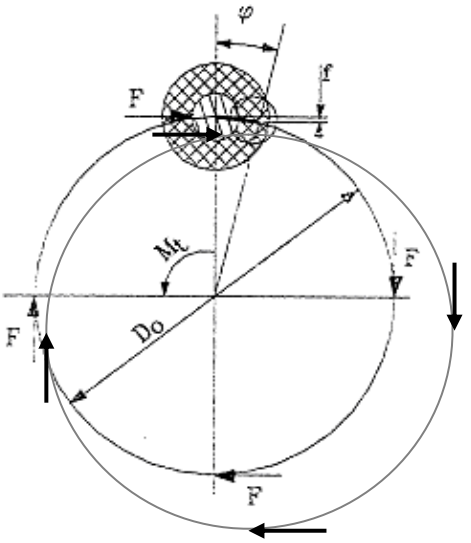


Figura 5.29

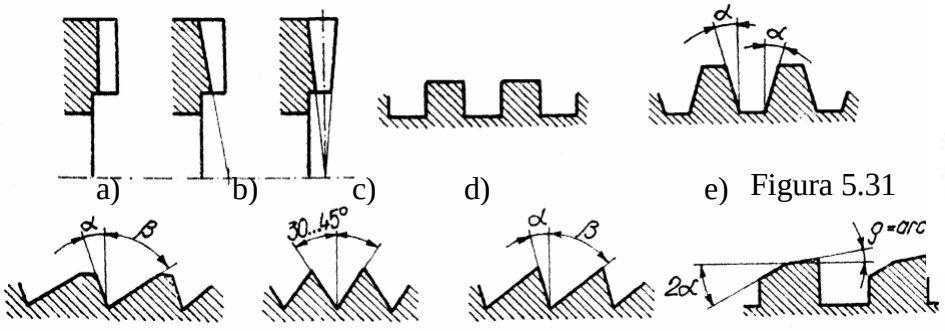


Figura 5.31

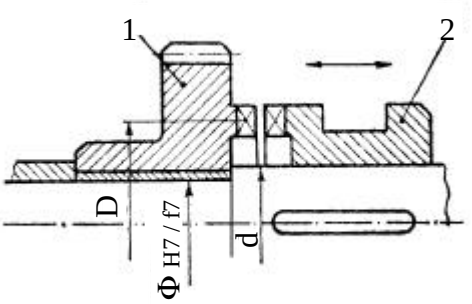


Figura 5.30

f) g) h) i)

$$F = \frac{2 \cdot M_t}{z \cdot D_0} \qquad (5.35)$$

$$F = c \cdot f^{\,a} \qquad (5.36)$$

$$f = \frac{D_0}{2} \cdot \phi \qquad (5.37)$$

$$M_t(\phi) = z \cdot c \cdot \left(\frac{D_0}{2}\right)^{a+1} \cdot \phi^{\,a} \qquad (5.38)$$

$$\sigma_i = \frac{M_i}{W_i} = \frac{F \cdot l_2}{\frac{\pi \cdot d_b^3}{32}} \le \sigma_{a\,i} = 60...80 \text{ MPa} \qquad (5.39)$$

$$\sigma_s = \frac{F}{d_b \cdot (l_1 - j)} \le \sigma_{s\,a} = 5...7 \text{ MPa} \qquad (5.40)$$

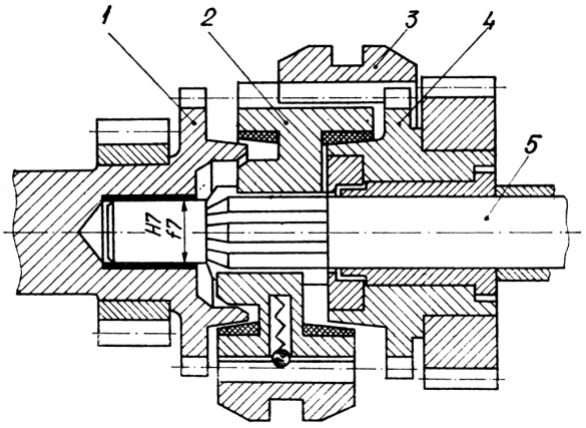


Figura 5.32

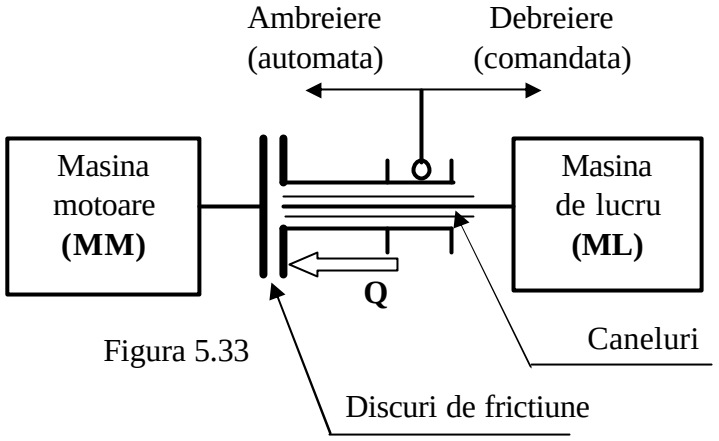


Figura 5.33

Tabelul 5.4

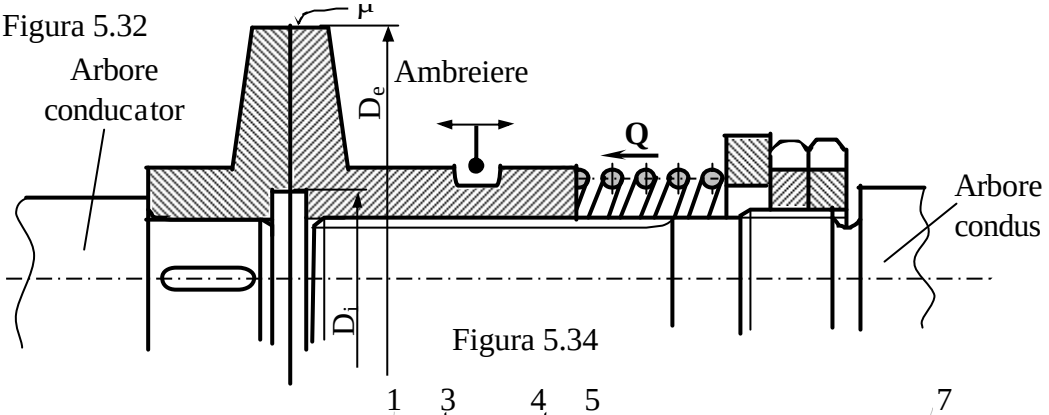


Figura 5.34

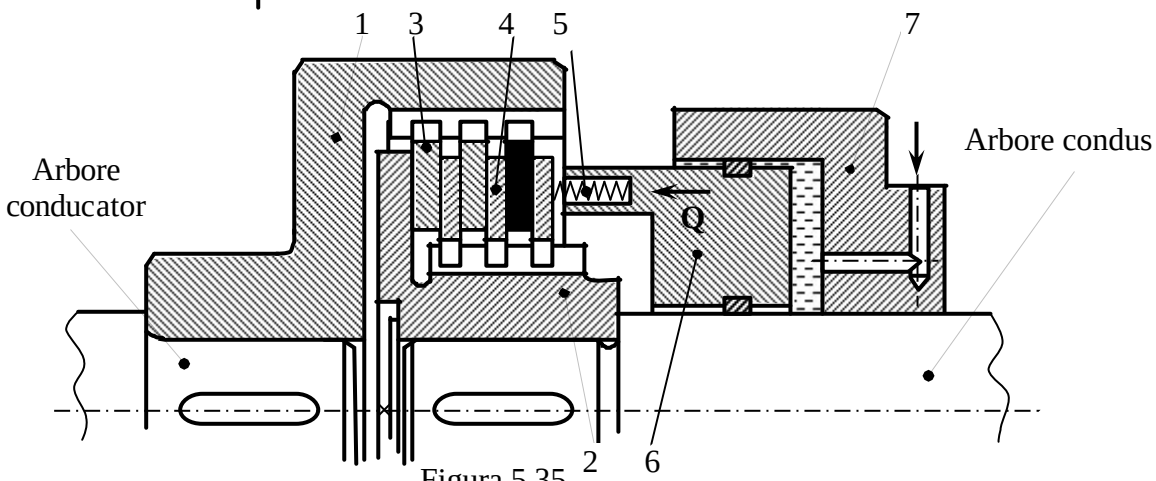


Figura 5.35

Regimul de frecare	
cu ungere	**fara ungere**
Otel calit / otel calit	-
Textolit / otel	-
Fc / Fc sau Fc / otel calit	
Bronz sinterizat / otel rectificat	
Tesatura de bumbac impregnata cu rasini sintetice / otel sau Fc	
Tesatura de azbest impregnata cu rasini sintetice / otel sau Fc	
Azbest presat cu rasini sintetice cu aschii de cupru sau de alama (ferodo) / otel sau Fc	
Cauciuc cu insertie metalica / otel sau Fc	
Materiale metalo-ceramice / otel calit	
Materiale din pulberi metalice / otel calit	

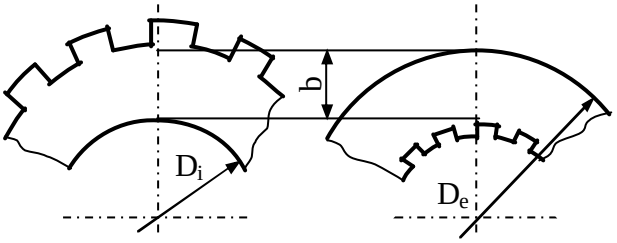


Figura 5.36

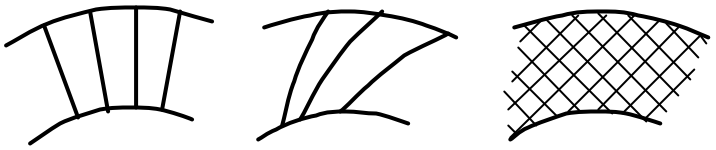


Figura 5.39

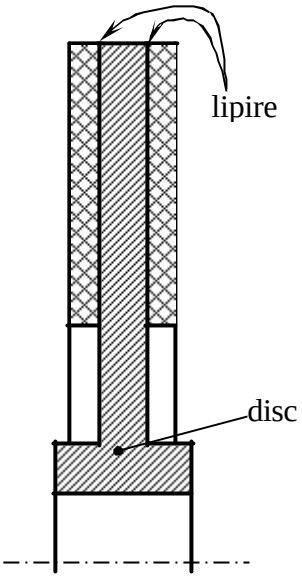


Figura 5.37

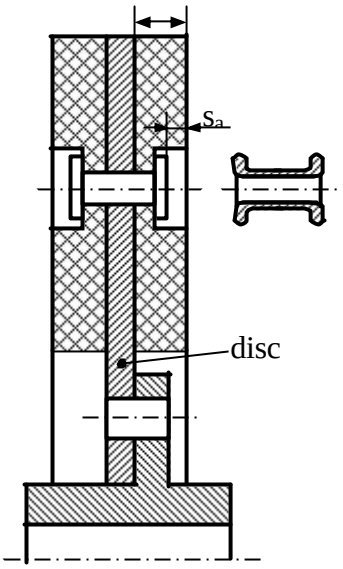


Figura 5.38

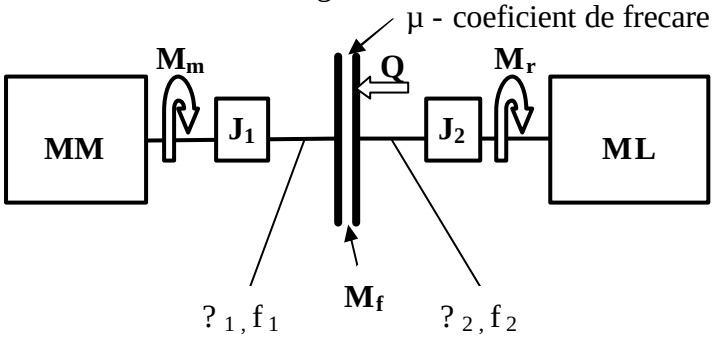


Figura 5.40

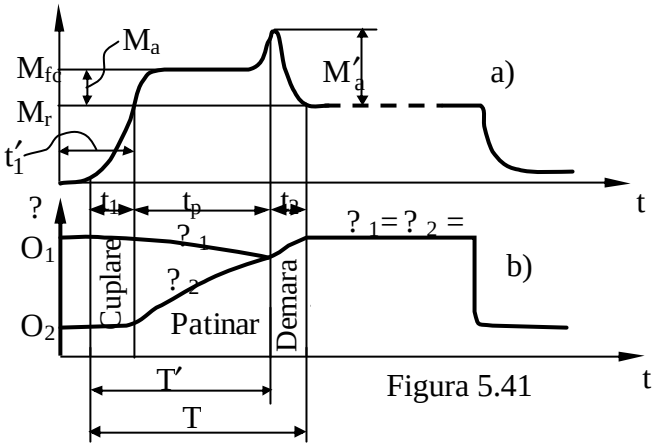


Figura 5.41

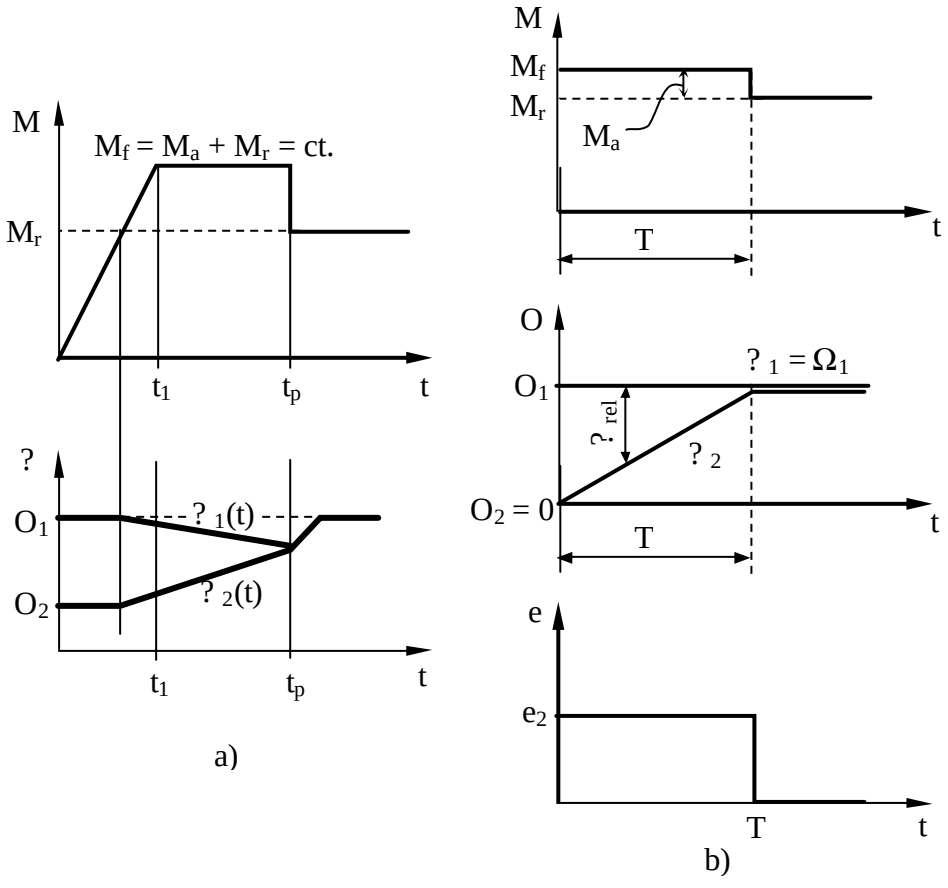


Figura 5.42

$$\begin{cases} J_1 \cdot \ddot{\phi}_1 + M_f = M_m \\ J_2 \cdot \ddot{\phi}_2 + M_r = M_f \end{cases} \quad (5.41)$$

$$\omega_1(t) = \frac{d\phi_1}{dt} = \frac{M_m - M_f}{J_1} \cdot t + \Omega_1 \quad (5.42)$$

$$\omega_2(t) = \frac{d\phi_2}{dt} = \frac{M_f - M_r}{J_2} \cdot t + \Omega_2 \quad (5.43)$$

$$\omega_r(t) = \omega_1(t) - \omega_2(t) \quad (5.44)$$

$$\omega_r(t) = \Omega_1 - \Omega_2 - \left(\frac{J_1 + J_2}{J_1 J_2} \cdot M_f - \frac{M_m}{J_1} + \frac{M_r}{J_2} \right) \cdot t \quad (5.45)$$

$$t_p = \frac{\Omega_1 - \Omega_2}{\frac{J_1 + J_2}{J_1 J_2} \cdot M_f - \frac{M_m}{J_1} - \frac{M_r}{J_2}} \quad (5.46)$$

$$\omega_r(t) = \Omega_1 - \left(\frac{M_f - M_r}{J_2} \cdot t + \Omega_2 \right) \quad (5.47)$$

$$t_p = \frac{\Omega_1 - \Omega_2}{M_f - M_r} \cdot J_2 \quad (5.48)$$

$$t_p = \frac{\Omega_1 \cdot J_2}{M_f} \quad (5.49)$$

$$M_f = \mu \cdot Q \cdot \frac{D_m}{2} \quad (5.50)$$

$$t_p = T = \frac{2 \cdot \Omega_1 \cdot J_2}{\mu \cdot Q \cdot D_m} \quad (5.51)$$

Tabelul 5.5

Timpul de ambreiere se reduce daca	**Conditiile din coloana stânga atrag si efecte negative, astfel:**
- viteza unghiuara O_1 este cât mai redusa	- reducerea vitezei unghiulare O_1 conduce la cresterea gabaritului masinii motoare
- momentul de inertie redus J_2 are valori cât mai scazute	- reducerea momentului de inertie J_2 – benefica, din punct de vedere al gabaritului, conduce la dificultati în proiectarea masinii de lucru care trebuie sa fie cît mai compacta
- coeficientul de frecare μ este mare	- cerinta alaturata poate fi respectata optând pentru un regim de frecare la limita sau pentru unul cu frecare uscata, dar uzura garniturilor de frictiune este intensa si durabilitatea ambreiajului este modesta
- forta de ambreiere Q este foarte mare	- consecinta secundara a cerintei este supradimensionarea sistemului care asigura realizarea fortei de ambreiere Q (arcuri, rulment de presiune etc.) si, în plus, duce la solicitarea prin soc axial a întregului ansamblu
- diametrul mediu D_m este mare, asadar si diametrul exterior este mare	- consecinta cerintei alaturate este cresterea gabaritului radial al ansamblului

$$P_f(t) = M_f \cdot \omega_r(t) \quad (5.52)$$

$$W_f = \int_0^{t_p} P_f(t) \cdot dt = M_f \cdot \frac{(\Omega_1 - \Omega_2)^2 \cdot J_1 \cdot J_2}{2 \cdot [M_f \cdot (J_1 + J_2) - M_m \cdot J_2 - M_r \cdot J_1]} \quad (5.53)$$

$$W_f = M_f \cdot \frac{(\Omega_1 - \Omega_2)^2}{2 \cdot (M_f - M_r)} \cdot J_2 \quad (5.54)$$

$$W_m = M_m \cdot \Omega_1 \cdot t_p \quad (5.55)$$

$$\eta = 1 - \frac{W_F}{W_m} \quad (5.56)$$

$$W_m = M_m \cdot \Omega_1 \cdot \frac{\Omega - \Omega_2}{M_f - M_r} \cdot J_2 \quad (5.57)$$

$$\eta = 1 - \frac{1}{2} \cdot \frac{M_f}{M_m} \cdot \frac{\Omega_1 - \Omega_2}{\Omega_1} \tag{5.58}$$

$$\eta = 1 - \frac{1}{2} \cdot \frac{M_f}{M_m} \tag{5.59}$$

$$P_f = \frac{W_f \cdot z}{3600} \quad [W] \tag{5.60}$$

$$M_f = M_r \cdot c_i \cdot c_s \tag{5.61}$$

Tabelul 5.6

c_i		c_s	
1,0	daca avarierea ambreiajului conduce la oprirea masinii	1,0	daca masina de lucru are un mers uniform
1,2	daca avarierea ambreiajului conduce la avarierea masinii	1,0 ... 1,6	daca masina de lucru are un mers neuniform
1,6	daca avarierea ambreiajului conduce la avarierea mai multor masini	1,6 ... 2,5	daca masina de lucru are un mers puternic neuniform
2,0	daca avarierea ambreiajului poate conduce la pierderi de vieti omenesti		

$$M_f = \frac{1}{3} \cdot \mu \cdot Q \cdot \frac{D_e^3 - D_i^3}{D_e^2 - D_i^2} \tag{5.62}$$

$$Q = \frac{\pi}{4} \cdot p \cdot (D_e^2 - D_i^2) \tag{5.63}$$

$$D_e \geq \left[\frac{12 \cdot M_f}{p_a \cdot \mu \cdot (1 - k^3)} \right]^{\frac{1}{3}} \tag{5.64}$$

$$Q = \frac{\pi}{4} \cdot p_a \cdot (D_e^2 - D_i^2) \tag{5.65}$$

$$t_{mediu} = t_0 + \frac{P_f}{k \cdot A_c} \leq t_{admisibil} \tag{5.66}$$

$$k = 12,7 + 2,8 \cdot v_{aer} \tag{5.67}$$

Tabelul 5.7

Cuplul de materiale	**p_a [MPa]**	**Coeficientul de frecare μ**		**Temperatura admisibila $t_{admisibil}$ [°C]**	
		cu ungere	**fara ungere**	**regim permanent**	**regim intermitent**
Fc / Fc	1 ... 1,8	0,15 ... 0,25	0,02 ... 0,1	300	
Tesatura de bumbac cu rasini sintetice/Ol sau Fc	0,05 ... 1,2	0,4 ... 0,65	0,1 ... 0,2	100	150
Tesatura de azbest cu rasini sintetice/Ol sau Fc	0,35 ... 0,7	0,2 ... 0,4	0,1 ... 0,2	200	300
Bronz sinterizat/Ol sau Fc	0,2 ... 1	0,15 ... 0,25	0,09	180	
Ferodo/otel sau Fc	0,2 ... 0,8	0,2 ... 0,4	0,1 ... 0,5	180	400
Cauciuc cu insertie/Ol sau Fc	0,5 ... 0,8	0,4 ... 0,65	0,1 ... 0,2	250	300

$$h = \frac{\frac{\pi}{4} \cdot (D_e^2 - D_i^2) \cdot s_a}{P_f \cdot q_a} \qquad \left[\frac{mm^3}{Wh} \right] \tag{5.68}$$

$$i = m + c - 1 \tag{5.69}$$

$$M_f = \frac{1}{3} \cdot \mu \cdot Q \cdot i \cdot \frac{D_e^3 - D_i^3}{D_e^2 - D_i^2} \tag{5.70}$$

$$Q = p_a \cdot \frac{\pi}{4} \cdot (D_e^2 - D_i^2) \tag{5.71}$$

$$M_f = c_i \cdot c_s \cdot M_{t\,nominal}$$

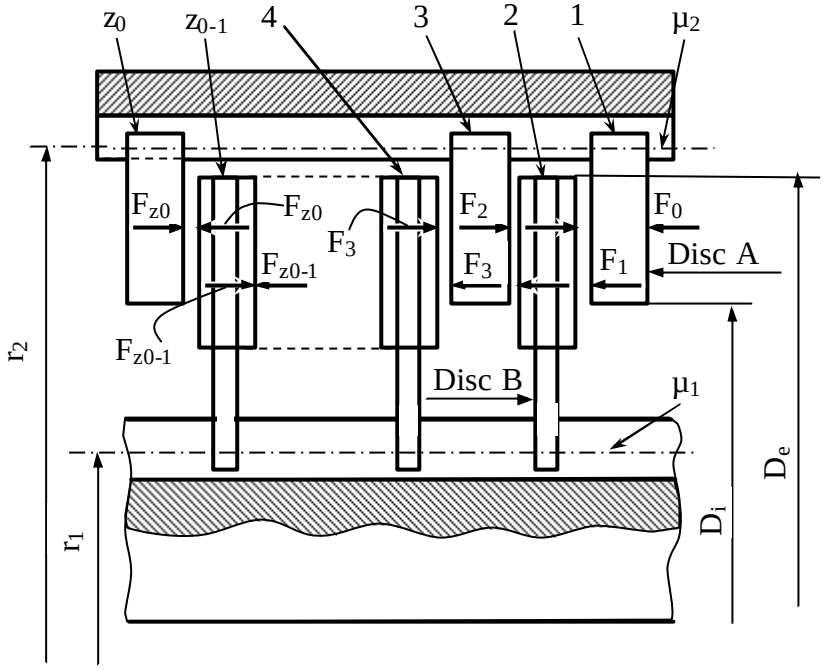


Figura 5.43

$$h = \frac{\frac{\pi}{4} \cdot (D_e^2 - D_i^2) \cdot i \cdot s_a}{P_f \cdot q_a} \tag{5.72}$$

$$Q = N \cdot (\sin\alpha + \mu \cdot \cos\alpha) \tag{5.73}$$

$$N = \frac{2 \cdot M_f}{\mu \cdot D_m} \tag{5.74}$$

$$N = p_a \cdot \pi \cdot D_m \cdot b \tag{5.75}$$

$$b \geq \frac{N}{\pi \cdot D_m \cdot p_a} \tag{5.76}$$

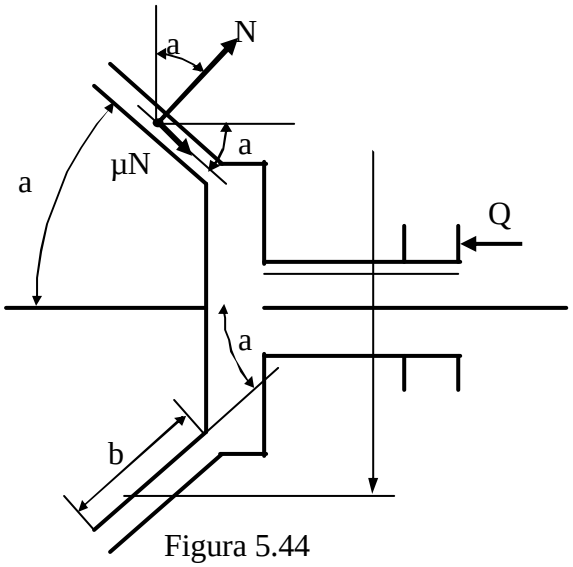


Figura 5.44

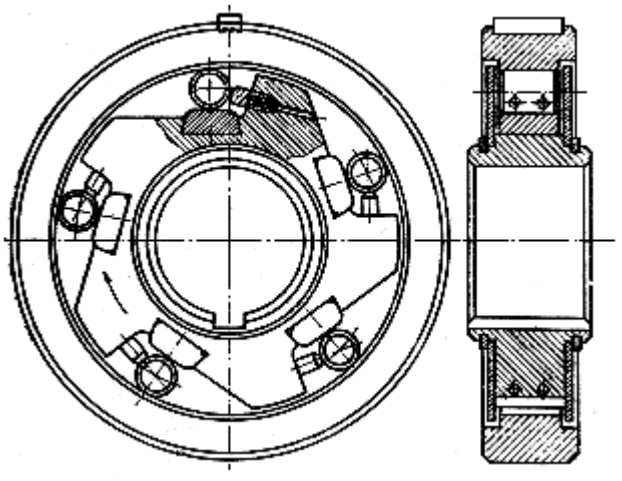


Figura 5.45

φ_1

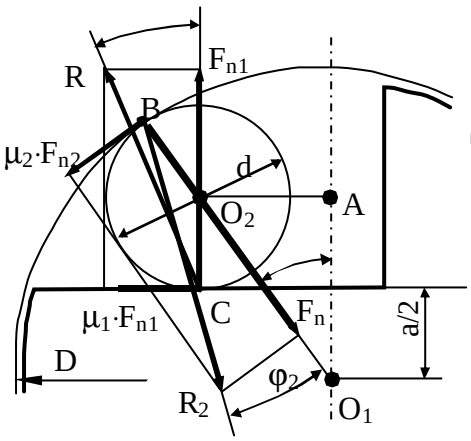


Figura 5.46

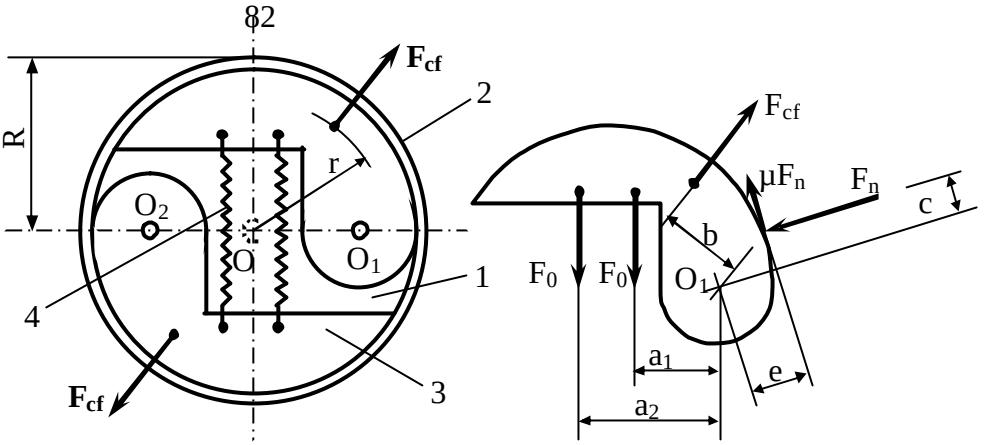


Figura 5.47

$$\frac{D-d}{2}\cdot\cos\alpha=\frac{a+d}{2} \tag{5.77}$$

$$F_0\cdot(a_1+a_2)-F_{cf}\cdot b+\mu\cdot F_n\cdot e+F_n\cdot c=0 \tag{5.78}$$

$M_f = M_{t\ calcul}$ unde: (5.79)

$$M_f=\mu\cdot z\cdot F_n\cdot R \tag{5.80}$$

$$F_{cf}=m\cdot r\cdot\omega^2 \tag{5.81}$$

$$m\cdot r\cdot\omega^2\cdot b-F_0\cdot(a_1+a_2)=\frac{M_{t\ calcul}}{\mu\cdot z\cdot R}\cdot(c+\mu\cdot e) \tag{5.82}$$

$$m\cdot r\cdot\omega_0^2\cdot b-F_0\cdot(a_1+a_2)=0 \tag{5.83}$$

$$m=\frac{M_{t\ calcul}\cdot(c+\mu\cdot e)}{\mu\cdot z\cdot r\cdot R\cdot b\cdot(\omega^2-\omega_0^2)} \tag{5.84}$$

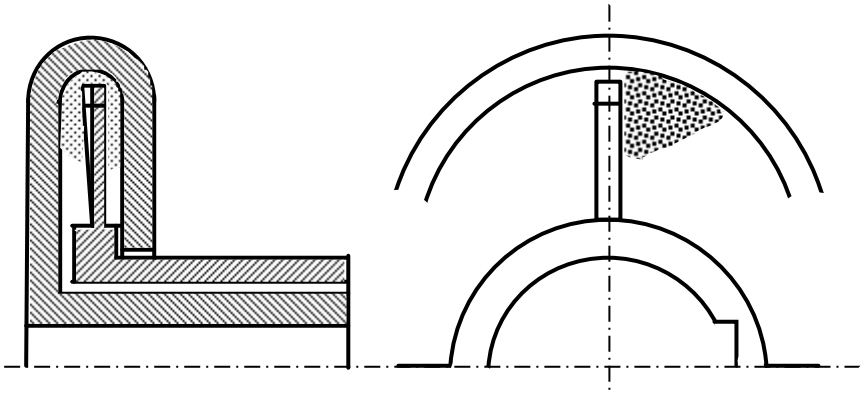


Figura 5.48

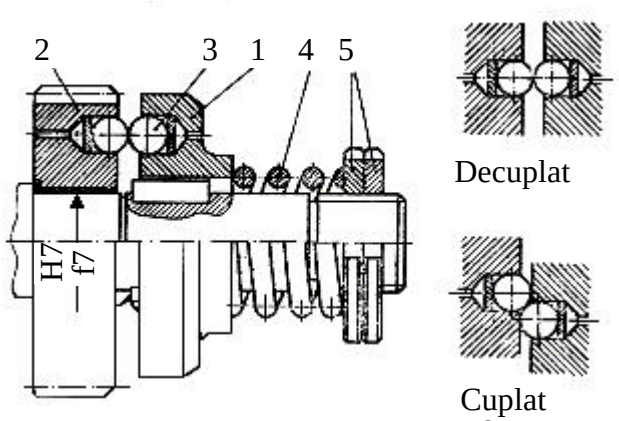


Figura 5.49