PMR2370

31 de outubro de 2011

1 Equações

Goodman

$$\frac{\eta\sigma_a}{\sigma_f} + \frac{\eta\sigma_m}{\sigma_t} = 1 \tag{1}$$

ASME

$$\left(\frac{\eta\sigma_a}{\sigma_f}\right)^2 + \left(\frac{\eta\sigma_m}{\sigma_{esc}}\right)^2 = 1 \tag{2}$$

Gerber

$$\left(\frac{\eta\sigma_a}{\sigma_f}\right)^2 + \left(\frac{\eta\sigma_m}{\sigma_t}\right)^2 = 1 \tag{3}$$

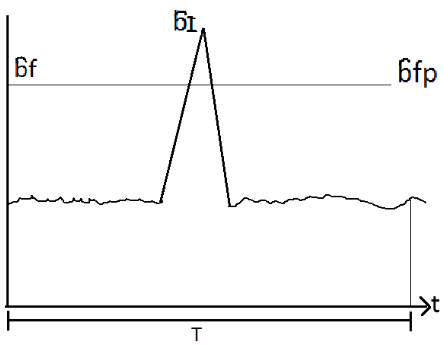

Figura 1:

2 Dano Cumulativo

Palmgren - Miner

$$\sum_{i=1}^{m} \frac{n_i}{N_i} = 1$$

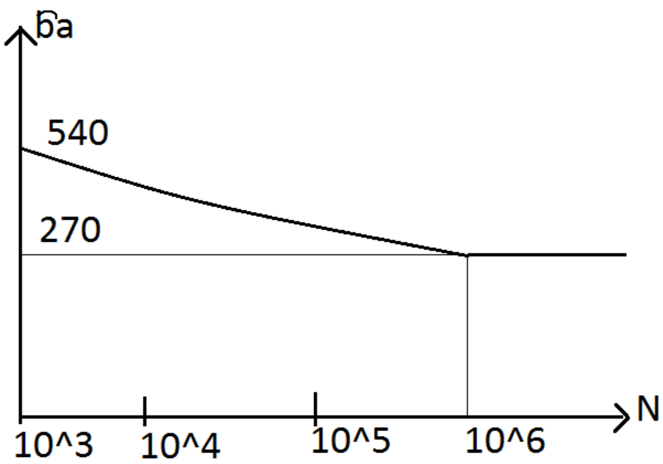

Figura 2:

n = 3000 ciclos @ 480 MPa

$$\sigma_a = 540 - \frac{(540-270)}{3}\left[\log(N) - 3\right]$$

3 Enunciado

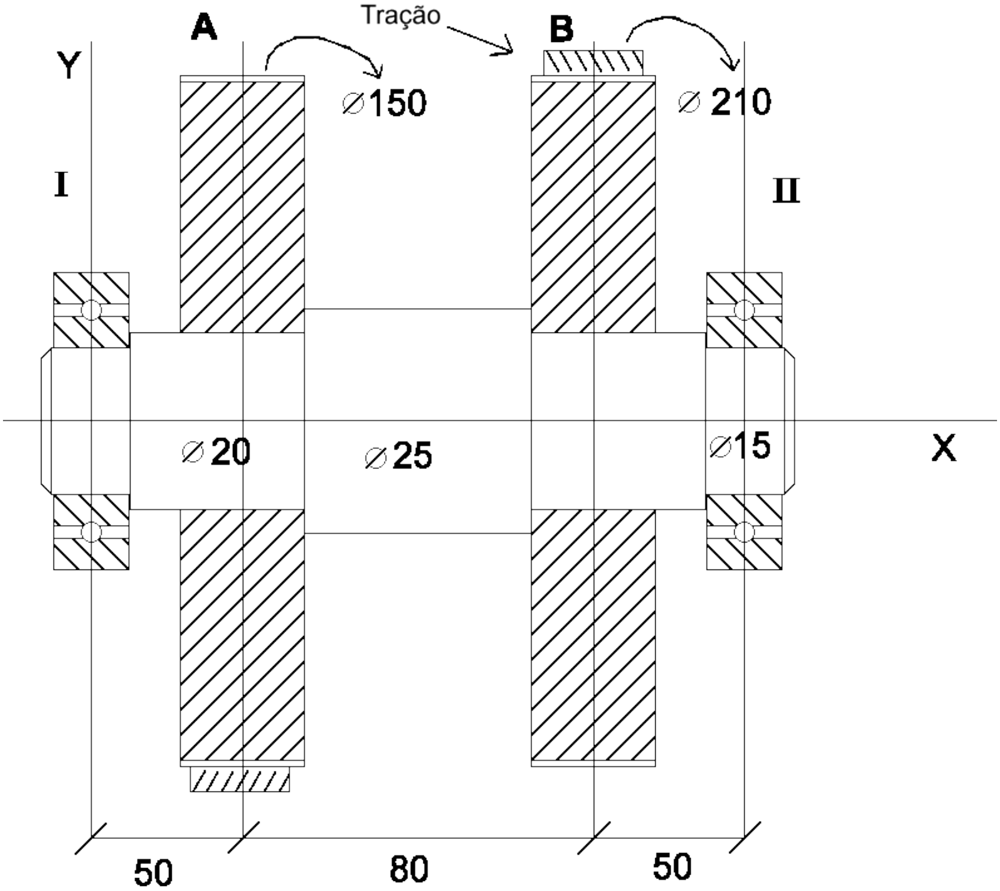

Figura 3: Transmissão

$$F_r = F_T \tan(\alpha)$$
$$ECDR$$
$$\alpha = 20^o$$

- σ_t=630 MPa σ_{esc}=420 MPa
- confiança 99%
- Acoplamento Superficial: retificado / torneado
- R = 1 mm N = 66 W n = 600 rpm

Solução

$$N = M_t \omega$$
$$6 = M_t \frac{600\pi}{30}$$
$$M_t = 95 Nm$$

$$F_{T,A} = \frac{M_t}{d_A/2} = \frac{95}{0.15/2} = 1267N$$
$$F_{T,B} = \frac{M_t}{d_B/2} = \frac{95}{0.21/2} = 905N$$
$$F_{R,A} = F_{T,A}\tan(\alpha) = 461N$$
$$F_{R,B} = F_{T,B}\tan(\alpha) = 329N$$

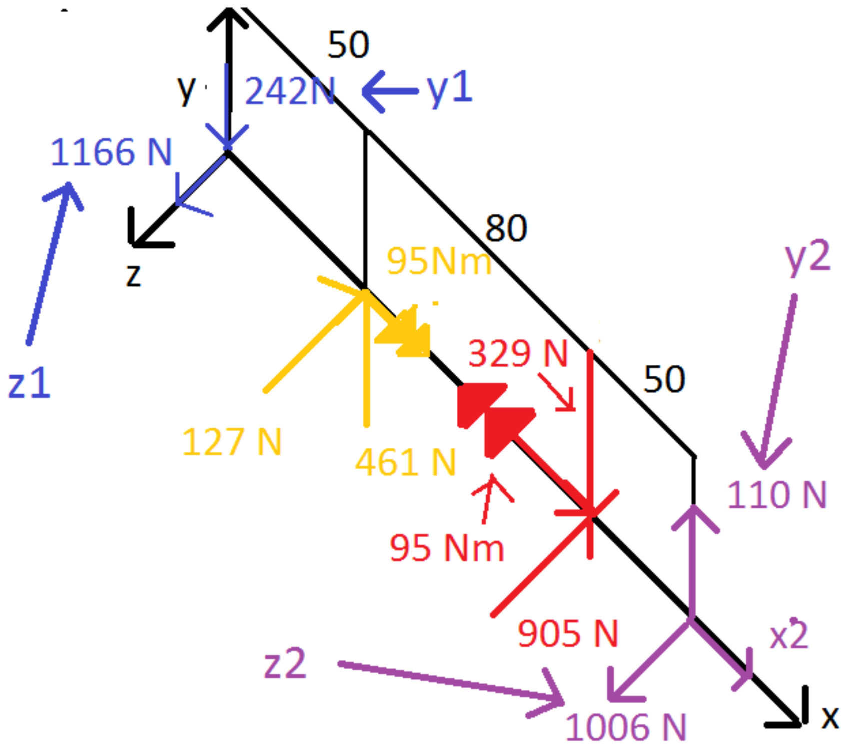

Figura 4: 1

$$\sum F_x = 0$$

$$\sum F_y = 0$$
$$X_{II} = 0$$
$$y_I + 461 - 329 + y_{II} = 0$$
$$y_I + y_{II} = -132(N)$$
$$\sum F_z = 0$$
$$z_I - 1267 - 905 + z_{II} = 0$$

$$\sum M_{yII} = 0$$
$$Z_I * 180 - 1267 * 130 - 905 * 50 = 0$$
$$Z_1 = 1166N$$
$$Z_2 = 1006N$$

$$\sum M_{zII} = 0$$
$$y_I * 180 + 461 * 130 - 329 * 50 = 0$$
$$y_1 = -242N$$
$$y_2 = 110N$$

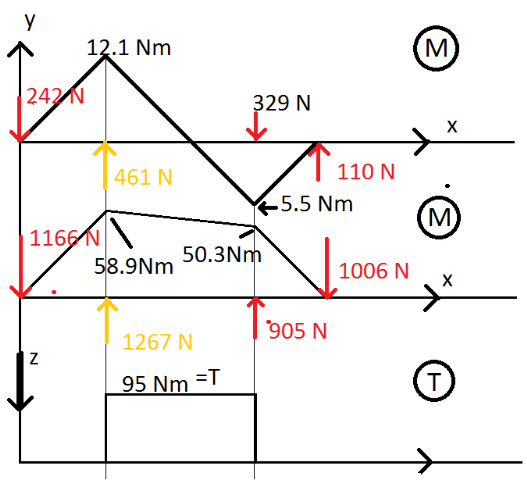

Figura 5: Diagrama de esforços solicitantes

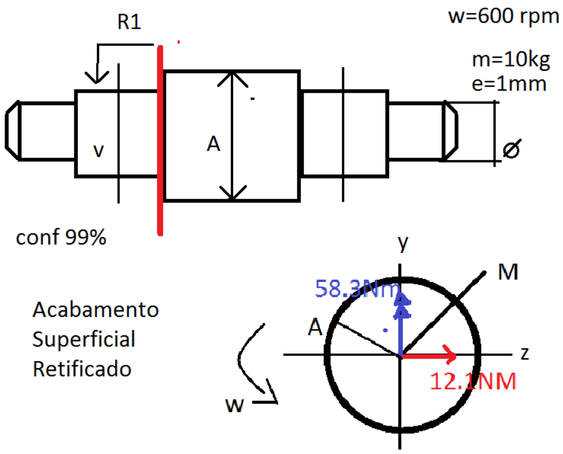

Figura 6: M $= \sqrt{58.3^2 + 12.1^2} = 59.5Nm$

Apesar dos momentos máximos atuarem no meio do comprimento da engrenagem, a favor da segurança vamos assumir que esses esforços se encontram na região de concentraçao de tensão.

Acabamento superficial retificado

$$\sigma_t = 630MPa$$

$$\sigma_y = 420MPa$$

$$\sigma^1 = \frac{32M}{\pi d^3} K_\sigma$$

$$\tau^2 = \frac{16T}{\pi d^3}$$

$$k_{t,\tau} = 2.0 \qquad q = 0.9$$

$$k_\tau = 1 + (2-1) * 0.9 = 1.9$$

$$\sigma_a = \frac{32 * 59.5 * 10^3 * 1.9}{\pi * 20^3} = 143.5Mpa$$

$$\tau_m = \frac{16 * 95 * 10^3}{\pi * 20^3} = 60,5Mpa$$

[1]variável

[2]constante

$$(\frac{\eta\sigma_a}{\sigma_{fp}})^2 + (\frac{\eta\sigma_m}{\sigma_y})^2 = 1$$

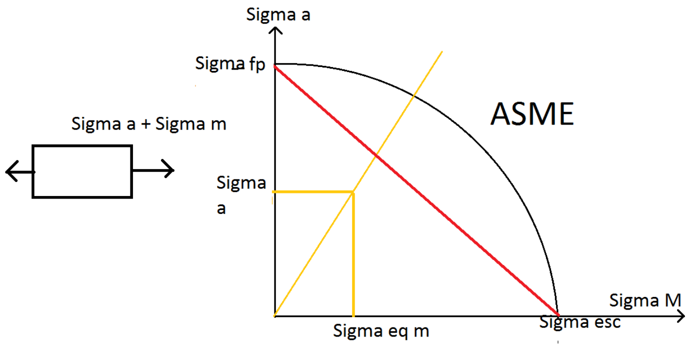

Figura 7: 4

η = fator de segurança

$$\sigma_{eqa} = \sigma_a = 143.5Mpa$$
$$\sigma_{eqm} = \sqrt{\sigma_m^2 + 3\tau_m^2} = \sqrt{1.8^2 + 3 * 60.5^2} = 105Mpa$$

Conf.	Kconf
80%	1
90%	0.897
99%	0.814
99.9%	0.753

$$\sigma_{fp} = 198MPa$$

$$k_{tam} = \left\{(d * 7.62)^{-0.107}; 2.80 <= d_1 <= 51mm\right\}$$
$$k_{tam} = \left\{1.51 * d^{-0.157}; d > 51mm\right\}$$

$$\sigma_{eq,a} = \sigma_a = 143.5MPa$$
$$\sigma_{eq,m} = \sqrt{3}\tau_m = 104.8MPa$$
$$\sigma_{fp} = \sigma_f k_{os} k_{conf} k_{tam} k_\theta = \frac{\sigma}{2} * 0.86 * 0.814 * 0.9 * 1$$

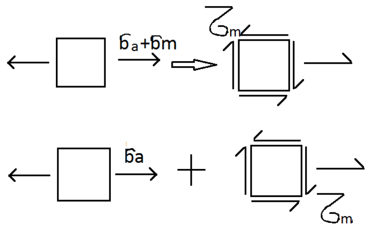

Figura 8: 5

$$\eta^2[(\frac{143.5}{198})^2 + (\frac{104.8}{420})^2] = 1$$
$$\eta^2 = 1.7$$
$$\eta = 1.3$$

Soderberg

$$\eta\frac{\sigma_a}{\sigma_{fp}} + \eta\frac{\sigma_m}{\sigma_y} = 1$$
$$\eta = 1.04$$

Hipótese:

$$\sigma_a = \frac{32M_e}{\pi d^3}K_\sigma$$
$$\tau_a = \frac{16T_a}{\pi d^3}K_\tau$$
$$\sigma_m = \frac{32M_m}{\pi d^3}$$
$$\tau_m = \frac{16T_m}{\pi d^3}$$

n=600 rpm, m = 10 kg, e = 1mm

engrenagem desbalanceada

$$\sigma_{db} = \frac{32M_{db}}{\pi d^3} = 1.8MPa$$

$$\sigma_{eq,m} = \sqrt{3\tau_m^2 + \sigma_m^2} = 10.5MPa$$

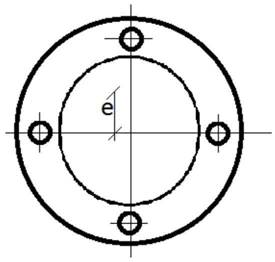

Figura 9: $F_c = m\omega^2 e = 10 * 63^2 * 1 * 10^{-3} = 40N$

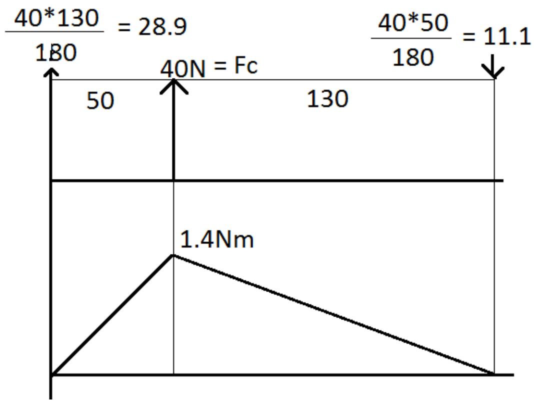

Figura 10: Diagrama de Momento

Assumindo agora:

$$\frac{\sigma_a}{\sigma_{fp}} + \frac{\sigma_m}{\sigma_y} = \frac{1}{\eta}$$

Hipótese

- σ flexão
- τ torção

$$\sigma_{eq,a} = \sqrt{\sigma_a^2 + 3\tau_a^2}$$
$$\sigma_{eq,m} = \sqrt{\sigma_m^2 + 3\tau_m^2}$$
$$\sigma_a = \frac{32M_a}{\pi d^3} k_\tau$$

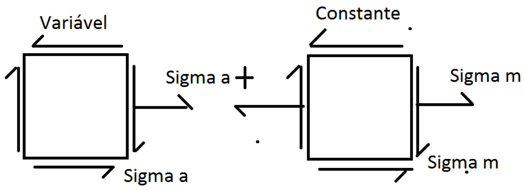

Figura 11: Hipóteses de flexão e torção

$$\tau_a = \frac{16T_a}{\pi d^3} k_\tau$$

$$\sigma_{eq,a} = \frac{16}{\pi d^3} \sqrt{4M_a^2 k_\tau^2 + 3T_a^2 k_\tau^2}$$

$$\sigma_{eq,m} = \frac{16}{\pi d^3} \sqrt{4M_m^2 k_\tau^2 + 3T_m^2 k_\tau^2}$$

$$\frac{16}{\pi d^3} \left[\frac{\sqrt{4M_a^2 k_\tau^2 + 3T_a^2 k_\tau^2}}{\sigma_{fp}} + \frac{\sqrt{4M_m^2 k_\tau^2 + 3T_m^2 k_\tau^2}}{\sigma_y} \right] = \frac{1}{\eta}$$

Com $\eta = 1.5$, pelo critério de Soderberg

$$d = \left[\frac{16}{\pi} \left(\frac{\sqrt{4M_a^2 k_\tau^2 + 3T_a^2 k_\tau^2}}{\sigma_{fp}} + \frac{\sqrt{4M_m^2 k_\tau^2 + 3T_m^2 k_\tau^2}}{\sigma_y} \right) \right]^{\frac{1}{3}}$$

ASME

$$d = \left[\left(\frac{16}{\pi} \right)^2 \left(\left(\frac{\sqrt{4M_a^2 k_\tau^2 + 3T_a^2 k_\tau^2}}{\sigma_{fp}} \right)^2 + \left(\frac{\sqrt{4M_m^2 k_\tau^2 + 3T_m^2 k_\tau^2}}{\sigma_y} \right)^2 \right) \right]^{\frac{1}{6}}$$

Fórmulas de WestingHouse para cálculo de eixo