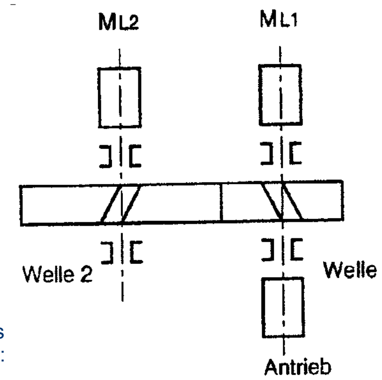
Break-Away Torque Calculation for 2 Gear Rotor Shafts

Below is an example calculation method for the "initial torque" which must be used by the driving machine to achieve dynamic rotation from a static condition. This is based on the gear rotor set coupled to the rotor of the driven machine. Both the **"direction of rotation"** and the **"break-away torque of the driven rotor (compressor/generator)"** must be known since the final friction strengths are dependent on the calculation for the gearing.

Calculation for 2 rotor shafts

M_L = Combined Break Away Torque of Driven Machine(s) (Nm)
F_U = Force at point of rotation @ pitch line (N)
G = rotor weight {pinion or wheel} (N)
L = Breaking Strength of Bearings from F_u and G (N)
F = force on the pitch circle to overcome friction (N)
R = pitch circle radius {pinion or wheel} (mm)
r = bearing journal radius (mm)
μ = friction factor - journal sleeve type bearing (0.26)
μ = friction factor - roller bearing (0.01)
μ = friction factor – roller/axial bearing (0.03)
M_R = friction moment (Nm)
↑↓ = working rotor movement (up force or down force)



note: if rotor weight "G" values are not given then approximate weights can be calculated as follows: G_g or G_p = (0.2215 x FW x d)*1.1 where: FW = gear tooth face width; d = rotor diameter; 1.1 (10%) is added for rotor shafts

Shaft 2 – Driven Rotor

Rotational force required for taking into account the driven machines break-away torque

$$F_{U_2} = 1000 \cdot \frac{M_{L2}}{R_2} \quad [1]$$

Net breaking force for driven rotor bearings derived from F_{U_2} and G_2

$$L_2 = F_{U_2} \pm G_2 \quad [2]$$

G_2 is negative if force direction on driven rotor mesh is up ↑ (up mesh)
G_2 is positive if force direction on driven rotor mesh is down ↓ (down mesh)

Net Rotational Force to overcome bearing friction on driven rotor

$$F_2 = \frac{L_2 \cdot \mu}{\frac{R_2}{r_2} \mp \mu} \quad [3]$$

μ is positive if force direction on driven rotor mesh is up ↑ (up mesh)
μ is negative if force direction on driven rotor mesh is down ↓ (down mesh)

Total driven rotor force

$$F_{U_{12}} = F_{U_1} + F_2 \quad [4]$$

Shaft 1 – Driving Rotor

Force on driving rotor derived from F_u and G_1

$$L_1 = F_{u_{12}} \pm G_1 \quad [5]$$

G_1 is positive if force direction on driving rotor mesh is down ↓ (up mesh)
G_1 is negative if force direction on driving rotor mesh is up ↑ (down mesh)

Total combined moment due to friction from both driving/driven Rotors

$$M_{R_1} = \frac{L_1 \cdot \mu \cdot r_1}{1000} \quad [6]$$

Total Break-Away Torque for this rotor set

$$M_{L_{ges}} = \frac{F_{U_{12}} \cdot R_1}{1000} + M_{R_1}\left(+M_{L_1}\right) \quad [7]$$

- *- including the coupled machine*

The driver is like a shaft rope coupled to the drive. Unlike the driven break-away torque, the driver break-away torque M_{L1} does not have any influence on the gearing. This is added to the total break-away torque of the gearing at the drive flange.

EXAMPLE:

M_{L_2} = 400 Nm - assumed break-away torque of driven machine

G_2 = 5000 N - wheel rotor weight

R_2 = 200 mm - wheel pitch line radius

r_2 = 65 mm - wheel journal radius

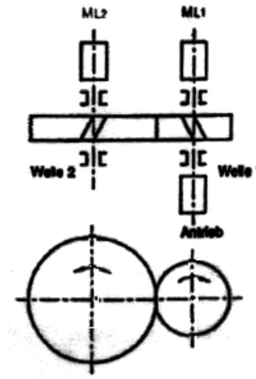
G_1 = 2000 N - pinion rotor weight

R_1 = 140 mm – pinion pitch line radius

r_1 = 45 mm – pinion journal radius

μ = 0.26 – friction factor

Beispiel:



Shaft 2: Shaft 1:

$$F_{U_2} = 1000 \cdot \frac{400}{200} = 2000 \Uparrow Nm \qquad L_1 = 2234 \Downarrow + 2000 \Downarrow = 4234 \Downarrow N$$

$$L_2 = 2000 \Uparrow - 5000 \Downarrow = 3000 \Downarrow N \qquad M_{R_1} = \frac{4234 \cdot 0.26 \cdot 45}{1000} = 49.5 N$$

$$F_2 = \frac{3000 \cdot 0.26}{\frac{200}{65} + 0.26} = 234 N \qquad M_{1_{ges}} = \frac{2234 \cdot 140}{1000} + 49.5 = \underline{\underline{362.3 Nm}}$$

$$F_{U_{12}} = 2000 + 234 = 2234 \Uparrow N$$

- note: add M_{L1} to obtain the total drive train break away torque.