Calculations concerning the shaft

a)

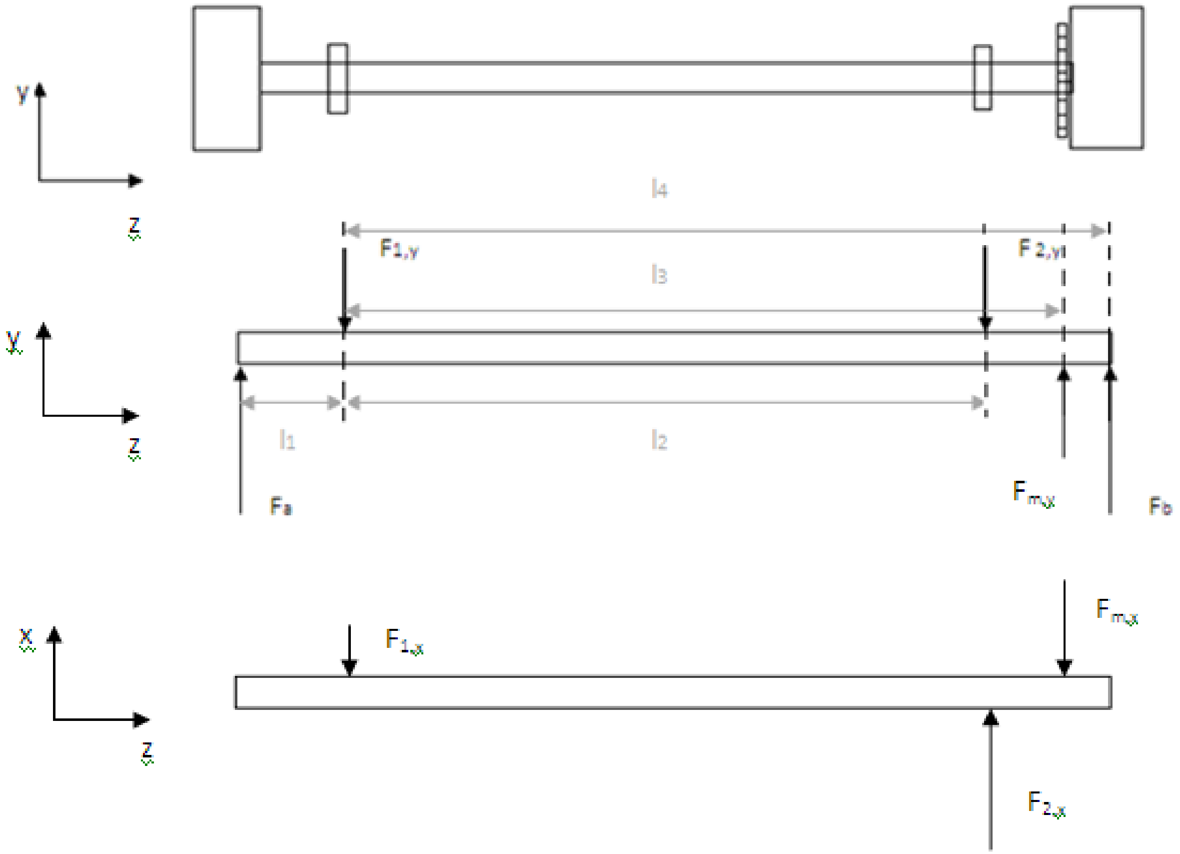

Figure: 2D-drawings of axle.

b)

- 2 x wheels
- 2 x Bearings
- 1 x Gear

c)

$F_a = F_b = ½ m * g = ½ * 0.962 * 9.81 = 4.72$ N

->If $T_m = 5.09 * 10^{-3}$ Nm (Tm = maximum torque of motor)

$F_m = T_m / R_1 = (5.09 * 10^{-3}) / (3 * 10^{-3}) = 1.70$ N

- ⇨ $F_{m,x} = F_m * \cos(20°) = 1.59$ N
- ⇨ $F_{m,y} = F_m * \sin(20°) = 0.58$ N

Given: $l_1 = 28.5$ mm

$l_2 = 208$ mm

$l_3 = 230$ mm

$l_4 = 245$ mm

y:

$\sum F_y = 0$

$F_{1,y} + F_{2,y} = F_a + F_b + F_{m,y}$

$\sum M_1 = 0$

$-F_a * l_1 – F_{2,y} * l_2 + F_{m,y} * l_3 + F_b * l_4 = 0$

=> $F_{2,y} = F_{m,y} * l_3 – F_a * l_1 + F_b * l_4 = 5.55$ N

=> $F_{1,y} = F_a + F_b + F_{m,y} – F_2 = 4.47$ N

x:

$\sum F_x = 0$

$F_{2,x} = F_{m,x} + F_{1,x}$

$\sum M_1 = 0$

$F_{2,x} * l_2 – F_{m,x} * l_3 = 0$

=> $F_{2,x} = (F_{m,x} * l_3) / l_2 = 1.76$ N

=> $F_{1,x} = F_{2,x} - F_{m,x} = 0.16$ N

$M_{b,max} = (M_{b,y}^2 + M_{b,x}^2)^{(1/2)} = (186.5^2 + 33.3^2)^{(1/2)} = 189.4 * 10^{-3}$ Nm

$T_{max} = T_t / 2 = (T_m / i) / 2 = (5.09 * 10^{-3} / 7.38) / 0.345 = 345 * 10^{-3}$ Nm (Tt = Torque of gear)

Bending stress:

Given: $D = 6$ mm

$D = 5.4$ mm

$M_b = 189 * 10^{-3}$ Nm

$T_{max} = 945 * 10^{-3}$ Nm

$\sigma_b = M_b / w_b = (M_b * 32 * D) / [\pi * (D^4 – d^4)] = 25.9 \approx 26$ MPa

Torsion stress:

$\tau_T = T / w_T = (T * y_{max}) / I_p = [T * (D/2) * 16] / [\pi * (D^4 – d^4)] = 11.8 \approx 12$ kPa

Shear stress:

With: $y_z = (4\pi/3) * [(D / 2) + (d / 2)]$

$= (4\pi/6) * (D + d)$

$A = ½ * \pi * [(D / 2)^2 + (d / 2)^2]$

$= (\pi/8)(D^2 + d^2)$

$I = w_b * y_{max} = [\pi * (D^4\text{-}d^4)] / 64$

$\tau = (M_b * S_y) / (I* b_m) = (M_b * y_z * A) / [(\pi (D^4 – d^4) * (D – d)) / 64]$

$= [M_b * (4 / 6\pi) * (D + d) * (1 / 8) * (D^2 – d^2)] / [\pi (D^4 – d^4) * (D – d) / 64]$

$= 29.8$

≈ 30 kPa

d) In motion the shaft experiences some different forces.
The resistance in the bearings is a reason for little differences.
When the surface is not flat, the forces caused by the weight can peak to higher amplitudes.