Groep 11 Groep T Bram Govaerts, Jonas de Beckker,
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Calculation report

1.Critical analysis of the stresses in the driven shaft

Parameters:

Mg = 7.85N

Suppose weight distribution evenly spread over 4 wheels when vehicle speed and acceleration = 0

The normal force of every wheel: F_N=1.96N

Distance between wheels is 23cm.

Distance between left wheel and gear is 11.5.

Distance between left wheel and bearing is 3cm.

Distance between right wheel and gear is 11.5cm.

Distance between right wheel and bearing is 3cm

Radius spur gear, rS = 2.1cm

Radius pinion gear, rP = 0.25cm

Radius wheel rW = 4cm

So first of all we need to calculate the force transferred from the motor to the first gear.

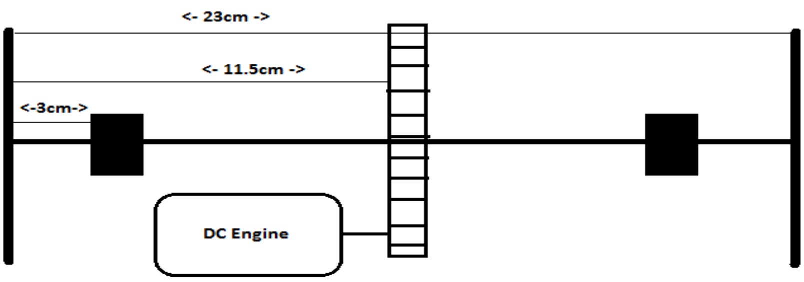
$$T_M = 8{,}55 * 70\% * I * 10^{-3}\ (Nm)$$

With T = Torque from the motor.
I = 0,9 A
Torque constant: 8,55 mNm/A
Constant Efficiency: 70%

The torque from the motor is than:

$$T_M = 0{,}00539\ Nm$$

Calculation:



Torsion stress to shear stress

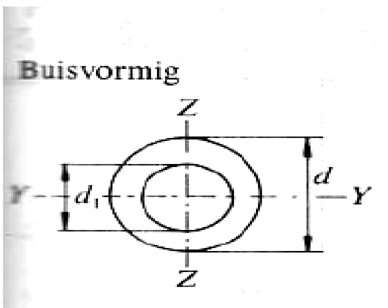
The torque of shaft:

$T_s = T_M \times r_s/r_p = 0.0453Nm$

So the torque of wheel:

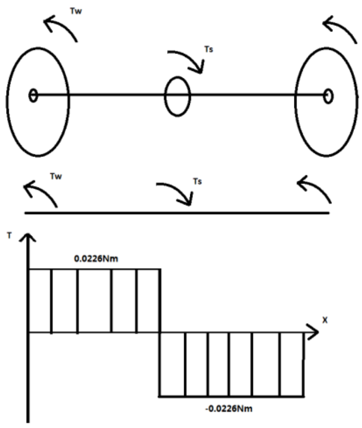
$T_w = T_S/2 = 0.0226Nm$

Our shaft is made by Aluminium and hollow. The D = 5mm and d = 4.5mm



$$I_y = I_z = \frac{\pi(d^4 - d_1^4)}{64}$$

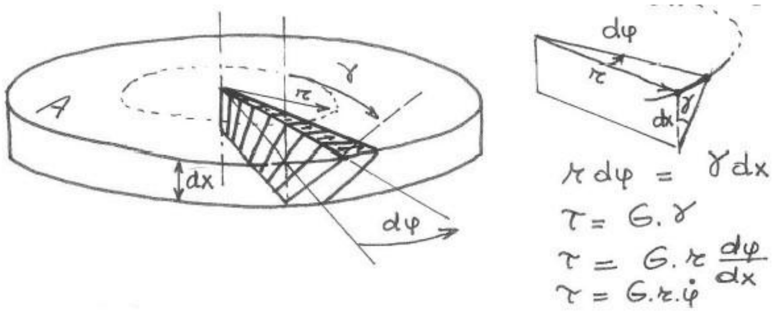
$$I_p = \frac{\pi(d^4 - d_1^4)}{32}$$



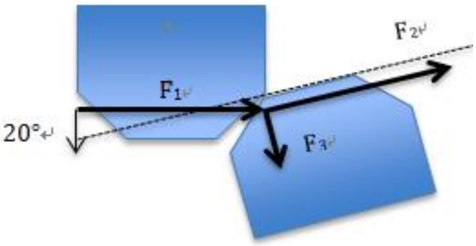
$$M_w = I_p \cdot G \cdot \varphi$$

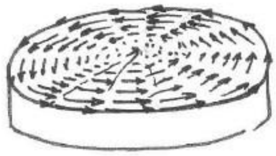
$$I_p = \frac{\pi \times (0.005^4 - 0.0045^4)}{32} = 2.11 \times 10^{-11} m^4$$

$$\tau_{max} = \frac{T \times R}{I_p} = 2.68 MPa$$



Bending stress

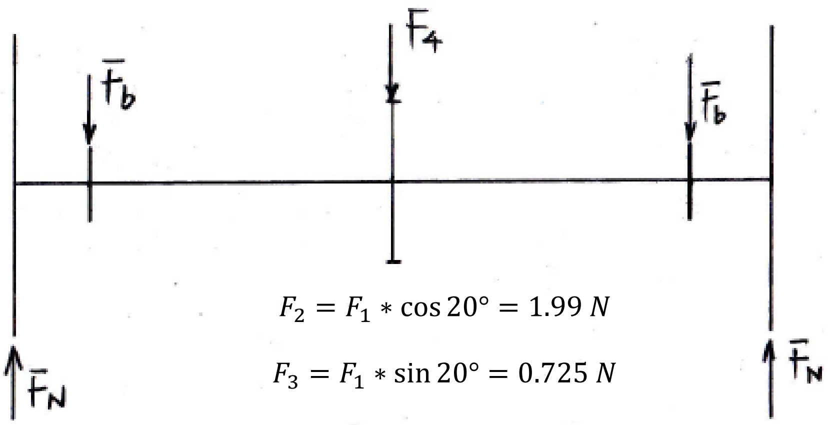




We now look at the forces generated by the pinion gear as a result of the gear teeth's contact area being at an angle of 20° to the plane connecting the centers of the 2 gears.

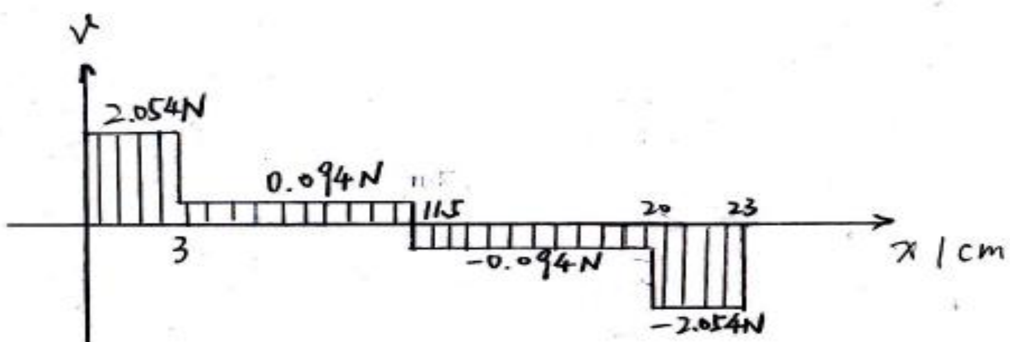
So $\mathrm{Fp} = \frac{T_M}{r_p} = 2.12N$

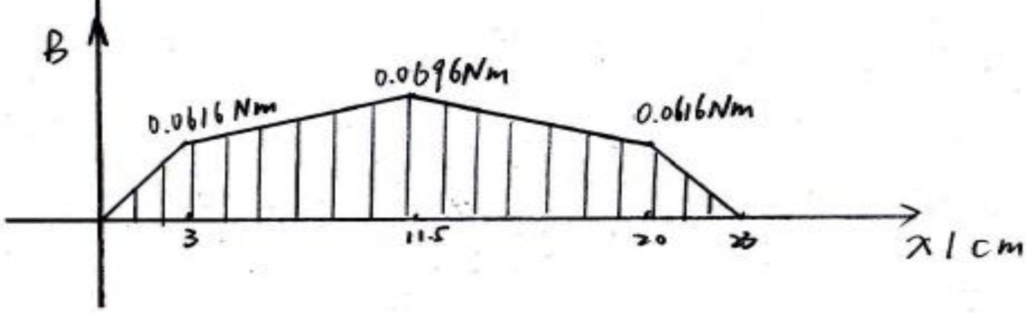
Now that we know the force from the smallest gear, we will be able to find the forces on the second and bigger gear due to the smaller gear.



$$F_2 = F_1 * \cos 20° = 1.99\ N$$

$$F_3 = F_1 * \sin 20° = 0.725\ N$$





Graph2

Therefore, there will be a force in vertical direction: F_4

We can get the value of angle φ: $\varphi = 15°$

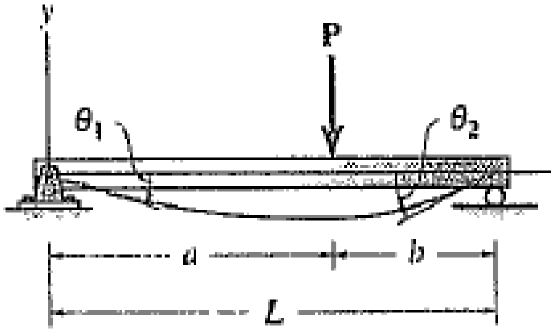
$F_4 = F_{3*} \times \sin 15 = 0.188N$

$F_5 = F_{3*} \times \cos 15 = 0.7N$

Fn = 2.054N

Fb = 1.96N

Mmax = 0.2698Nm



$\sigma = M \times y \div I_z$

$I_z = 1.055 \times 10^{-11} m^4$

$\sigma_{max} = 16.5MPa$

$$\tau_{max} = \frac{Vmax}{A} = \frac{2.054}{3.738 \times 10^{-6}} = 0.55MPa$$

In the direction ofF_4, because of its value is much smaller than the value of vertical direction. So we don't need to calculate it!

We have check the normal stress and shear stress of Aluminum. Our value form our calculation is smaller than data value. So our design is safe.

Data from

http://www.matweb.com/search/DataSheet.aspx?MatGUID=e5de9f1161d34f71a34ae016723d097f&ckck=1

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2.Sankey diagram

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This Sankey diagram shows us all the power losses in the Umicar, when racing in the top speed with batterys.

Here is the all value that be used during the calculation.

Mass:	225kg
Rolling resistance coefficient:	Crr = 0.0025 (theoretical, on 8 bar tire pressure)
Crr = 0.0056 (experimental, on 5 bar tire pressure)	
Average motor efficiency:	94%
Average controller efficiency:	99%
280 RWE solar cells:	30% average efficiency
2576 Emcore solar cells:	24.5% average efficiency
Frontal Area:	0.81m^2
Max Speed on Batteries:	75mph=33.54m/s
Active Area:	7.94m^2
Panel Conversion Efficiency:	24%
Array Voltage:	100V
Density of air:	ρ = 1,293 kg/m3
MOTOR AT DESIGN OPERATING POINT:	
Efficiency:	94%
Battery Pack Voltage:	96V

Caculations:

Solar radiation(100%):

$$\frac{800\text{w}}{\text{m}^2} * 7.94\text{m}^2 = 6352\text{w}$$

Reflection(76%):

$$6352\text{w} * 76\% = 4827.5\text{w}$$

Solar→Storage battery(24%):

$$6352\text{w} * 24\% = 1525\text{w}$$

Storage battery→DC motor(29.1%):

$$94\% * 31\% = 29.1\%$$
$$29.1\% * 6352\text{w} = 1848\text{w}$$

Mechanical Transmission losses(0.6%):

$$29.1\% * 2\% = 0.6\%$$
$$0.6\% * 6352\text{w} = 3811\text{w}$$

Roling resistance(2.9%):

$$P_r = F_r * V_{max} = m * g * v * C_r = 185\text{w}$$
$$\frac{185\text{w}}{6352\text{w}} = 2.9\%$$

Air resistance(12.9%):

$$P_{air} = F_{air} * V_{max} = \frac{1}{2} * C_w * A * \rho \; * v^3 = 819\text{w}$$

$$\frac{819\text{w}}{6352\text{w}} = 12.9\%$$