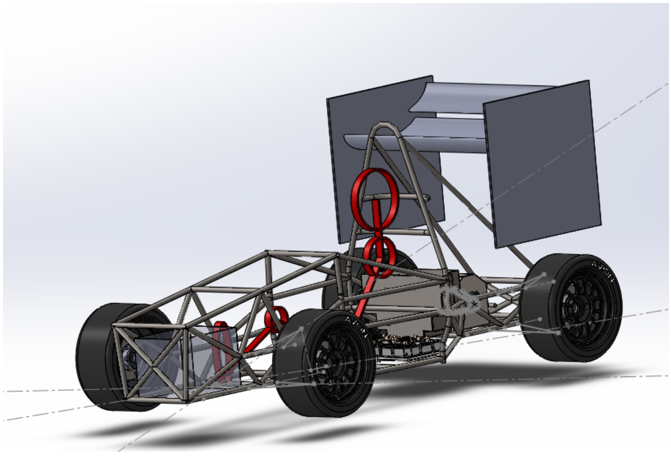
DESIGN OF REAR WING OF AN ELECTRIC RACE CAR



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Abstract

Race cars wooo! Formula studee3333nt

Contents

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Introduction

Vermilion Racing is a newly started Electric race car team building their first vehicle: The Eevee [1]. The teams' purpose is competing against other Universities at the Silverstone race track from the 11^{th} to the 16^{th}. As members of the team, the purpose of this report is to document the design process of the rear wing of the first car, the Eevee, and provide an aerodynamic package documenting drag and downforce. The intent is to start a student organization, passing on the teachings of racecar mechanics for many years to come.

Aerodynamics is a major decider in racing today. Cornering, not top speed is the deciding factor amongst the teams, and aerodynamics is the key. Drag, lift and side force are the three cornerstones to vehicle aerodynamics. A car's ability to handle depends on the grip of the tyres, and downforce directly increases grip by increasing the downwards load on the tyres without adding a weight penalty. Additionally, drag directly decreases the speed of a vehicle by increasing air resistance, but is of less importance as the car's in this class have far more accelerative power than the tyres can handle [2]. Designing the bodyworks of Eevee is therefore a dance of downforce.

1.1 Motivation

- Why are we designing this to begin with

1.2 Design Philosophy

- what are we designing for? low weight, high downforce. drag a bit neglegible due to high power motors.

1.3 Design restrictions

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Theory

First, let's explain what makes a car fast, and what parameters we can change to improve the speed of our car. The car's acceleration can be described by Newton's second law as:

FiXme Note: stort D eller lille d i ligningen?

$$\sum F_x = m\ddot{x} = F \tag{2.1}$$

Where the sum of forces in the x-direction (the direction of travel) can be expressed as the force already pertained by the vehicle, minus the drag force:

$$F - C_D\left(\frac{1}{2}\rho\dot{x}^2 A\right) = m\ddot{x} \tag{2.2}$$

Assuming we're moving at a steady speed, the acceleration is 0, hence

$$F = C_D\left(\frac{1}{2}\rho\dot{x}^2 A\right) \tag{2.3}$$

As we were interested in the speed of the car, let's solve for the velocity. The force is given by $F = \frac{P}{\dot{x}}$, where P is the power of the car, which gives:

$$\dot{x} = \left(\frac{2P}{C_D\left(\rho A\right)}\right)^{\frac{1}{3}} \tag{2.4}$$

This is assuming we're traveling at terminal velocity – that is, the point where the Driving Force = Friction Force. The terminal velocity of the racer is then easily calculated, as the competition restricts the maximum amount of power:

FiXme Note: Muligvis uddyb her

$$\dot{x}_{\mathrm{max}} = \frac{2 \cdot 80\,\mathrm{kW}}{0.85\left(1.225\,\mathrm{kg\,m^{-3}}\ 1.2\,\mathrm{m^2}\right)} = 50\,\mathrm{m\,s^{-1}} = 181.4\,\mathrm{km\,h^{-1}} \tag{2.5}$$

however, given the ruleset a forecasted maximum of $110\,\mathrm{km\,h^{-1}}$ allows a much larger drag coefficient C_D:

$$C_D = \frac{2P}{\dot{x}^3\,(\rho A)} = \frac{2 \cdot 80\,\mathrm{kW}}{(120\,\mathrm{km\,h^{-1}})^3\,\left(1.225\,\mathrm{kg\,m^{-3}}\;1.2\,\mathrm{m^2}\right)} = 2.82 \qquad (2.6)$$

Thus, the car's top speed will only be limited by a drag factor > 2.82, which is far above the drag introduced by the aerodynamic devices.

From this derivation, it's clear that the car's abilities at maximum speeds far exceed the requirement of the track. Therefore, the next step is to improve cornering speeds which depend strongly on the tyre's grip on the surface of the road [2].

2.1 Aerodynamics

2.2 Vehicle Performance

2.2.1 Improvements in Top Speed

2.2.2 Cornering performance

2.2.3 Load Distribution

3

Simulation

3.1 Star-CCM+

3.2 Finite Volume method

3.3 Mesh Generation

3.4 The Wing

3.4.1 Multi-Element Wing Optimization

Wing was moved around to optimize lift. Here's the results changing the variables.

3.5 The Aerodynamics Package

3.5.1 Undertray, Diffuser, Front Wing and Driver

3.5.2 Everything Together Now

3.6 Results

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Construction

4.1 Requirements

FiXme Note: Hvad kræves af styrke fra konkurrencens side? Hvad ønsker holdet?

4.2 Prototyping

4.3 Material Selection

FiXme Note: Overvej CES (for flair jo)

4.4 Molds

4.5 Assembly

4.6 Finish

5

Experiment

5.1 Equipment

5.2 Experimental Procedure

5.3 Results

6

Discussion

7

Conclusion

bla

Perspective

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