QUEEN'S UNIVERSITY BELFAST | SCHOOL OF MECHANICAL AND AEROSPACE ENGINEERING

Detailed project description form

Project title	**Design and manufacture of an aerodynamic undertray for Formula Student**	**Project ID number**	286
		Supervisor	**Dr Rob Watson**
Student name	**Dennise Zefanya Tohpati**	**Academic year**	2020-21
		Student number	**40222359**

Indicate the student cohort

Stage 3 (MEE3030)		*Stage 4 (AER4002/MEE4040)*		*Postgraduate (MEE7012)*	
BEng Aerospace Engineering (40 CATS)	✓	MEng Aerospace Engineering (60 CATS)		MSc Mechanical Engineering with Management (60 CATS)	
BEng Mechanical Engineering (40 CATS)		MEng Mechanical Engineering (40 CATS)		MSc Materials Engineering (60 CATS)	
BEng Product Design Engineering (40 CATS)					

Project background

Aerodynamics is one of crucial importance to the performance of high-speed cars. The drag at high speeds must be kept as low as possible to maximise the top speed and acceleration, whilst the downforce developed should be maximised as the car manoeuvres around corners. In addition, the change in the distribution of downforce over the surface of the car can also have serious consequences for the ease of handling of the vehicle. Getting this balance right can have a major impact on the lap times of the vehicle.

The racing rules of Formula Student allow for some fairly advanced forms of aerodynamic control – including complex passive systems. The work of previous years has seen the development of an Aerodynamics Roadmap, which outlines several ways in which the aerodynamics of the car can be improved and refined. One of the key aerodynamic devices which was identified in this roadmap was the undertray of the car. Some simple designs of undertray were tested computationally, and some broad recommendations were made.

This project would continue to build on these foundations for improved performances by Queen's Formula Racing by integrating an optimised aerodynamic design of undertray into the car – including a CAD model, materials specification, and, if progress and workshop time allow, a manufactured design.

Project aims and objectives

Project Aim:

- To design and optimise an aerodynamic undertray for Queen's Formula Racing through the results of simulations, review, and recommendation of existing literature.
- To take the design recommendations from Aerodynamic Roadmap for aerodynamics undertray from previous paper and explore and improve its performance to its optimised downforce and drag, both as an isolated component and as an integral part of the car.
- To develop an optimised undertray design for QFR 2021 car, including the material, CAD Model, and a system integration process.
- To manufacture and install an aerodynamic design for the QFR Car if progress and workshop capacity allows.

Project Objectives:

- Review the existing literature and previous paper of QFR aerodynamic map road to be the basis of understanding of the undertray design and look up the variables that could improve its performance.
- Analyse the enclosed and open flow 2D analyses with various inlet, outlet, and ground clearance variables have been performed using ANSYS Fluent to identify its effect on the undertray lift and drag.
- Design flexible 3D undertray designs based on the 2D analysis results, which then will again be optimised with additional aerodynamic features on the undertray which will improve the downforce and reduce the drag.
- Design the final undertray CAD and choose the material which tailored to car's dimension and goals, then analyse the weight to drag ratio to pick the best performance and material for the car.
- Manufacture and fit the undertray for 2021 Queen's Formula Racing car which then will be judged on the Formula Student competition. (**Update March 2021:** Due to the time constraints and the uncertainty of workshop capacity at this stage; therefore, it was decided that material analysis is not included in this report.)
- Write a final report of the undertray including the future research recommendation which then will be submitted in March 2021 as part of the BEng degree.

Project methodology and outline work plan

Project Methodology:

- Initial literature and previous papers review to obtain the general idea of how the undertray will be developed.
- Perform preliminary open and enclosed flow 2D analysis of the undertray with changes in variables: 1. Inlet angle, 2. Diffuser Angle using ANSYS Fluent. The open flow analysis will be done with QFR car-like shape on the top of the undertray to give more accurate lift and drag results.
- Identify the behaviour of the undertray based on the previous results and literature review.
- Design Preliminary 3D design with flexible dimensions, which later can be modified in purpose of fitting the 2021 Queen's Formula Car.
- Perform CFD analyses on the various proposed isolated 3D design using ANSYS Fluent.
- Optimisation of different parameters of the aerodynamic undertray design based on the previous CFD analyses.
- Material analysis of the undertray for manufacturing. (**Update March 2021:** Due to the time constraints and the uncertainty of workshop capacity at this stage; therefore, it was decided that material analysis is not included in this report.)
- Finalised the design and technical drawing which fit the dimensions to the QFR 2021 car which will be sent to be manufactured.

Gantt Charts or the project plan and meeting minutes are attached to Appendix E – Project Management

Project deliverable(s)

1. Design open and enclosed flow undertray with varying variables: 1. Inlet angle and 2. Outlet Angle
2. CFD analyses of the 2D open and enclosed flow using ANSYS Fluent with different turbulent models.
3. Design and optimise the 3D flexible design for Queen's Formula Student Undertray.
4. CFD analyses of the isolated 3D undertray open flow using ANSYS Fluent with different turbulent models.
5. Evaluate and optimise the finalised 3D design, which dimension-fit with the QFR 2021 car.
6. Material analysis of the undertray (**Update March 2021:** Due to the time constraints and the uncertainty of workshop capacity at this stage; therefore, it was decided that material analysis is not included in this report.)

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Mitigation plans and management for risks including for COVID-related issues

- This project will be performed solely computer-based, and no physical lab will be involved. The work plan has been adjusted by adding an additional week for every task due to the Covid-19 pandemic situation. This action has been carefully assessed to let student still achieve the best results in the timeline given.
- Due to the nature of the projects, some risks can occur, including headache due to screen glare and work-related upper limb disorder (WRULDs) due to a long-term improper working position that could lead to poor posture, ache, and pain.
- There have been many actions discussed to prevent the risk; some of them are using your workstation correctly (proper sitting posture & eye-screen distance), taking regular breaks from the screen, and adjusting the chair height to fit your workstation.

Supervisor feedback

This is an ambition project plan, but Dennise has already proved that he is capable of working diligently and sensibly, and has made good progress already.

The mitigations for issues due to Covid-19 are sensible, given the remote nature of the problem.

The biggest challenge remaining, given the current progress on the simulation side, is likely to be the manufacture and installation of the undertray on the car, and Dennise has set aside considerable time for that aspect within his plan.

Signatures

Student signature: Dennise Zefanya Tohpati — Date: 11th November 2020

Supervisor signature: — Date: 11th November 2020