SHEFFIELD FORMULA RACING

MARCH NEWSLETTER

CO-WRITTEN BY GEORGE POULTER & ASHLEY DAVISON

PROJECTS

Group Project

Each year, our third year mechanical engineers undergo a group design project which makes up 17% of the year. These projects are supplied by third parties such as industry, research institutes and student-led learning activities (such as Formula Student).

At Formula Student we self-propose related projects aimed at future concepts that require high-level design work. These typically wouldn't be achievable in our usual one-year design-manufacture-race time cycle. In the part these have included the likes of:

- Electrification
- Aerodynamics
- Composite Monocoques
- Drivetrain Efficiency
- Sustainability

The project itself is bigger than anything our students would have undertaken before as part of the degree.

The aim is to be innovative when developing the solution by applying a spectrum of the fundamental academia that has been studied in lower years. The project is split up into an individual report, group report and poster presentation.

This year we have one group working on the title "Advanced Powertrain Design". The aim of the project is to look at the potential for a hybrid powertrain Formula Student car and to answer the following questions:

- Which hybrid system would be optimum?
- Is it going to increase the performance in different aspects of comp?
- Where will these points be gained (and where will points be lost)

The project team is made up of four team members (Tom Nalson, Eddie Warden, Sam Harris, Matt Boland) and two other non-SFR students (James Dorey and Thomas Richards). The hope is that the outcome of this project will feed directly into our electrification project that the team is currently working towards.

The University Of Sheffield.

Final Year Project

All final year masters students undertake an individual project which makes up for 38% of the year. This gives our students the chance to bring together the knowledge and experience they have gained throughout their degrees into one individual piece of work. Like the group project, titles are supplied by a variety of industry companies, research institutes and from Sheffield's own research programme. Many of these projects also form part of a PhD programme.

Our students are also able to self-propose a project if they have a particular interest. These would typically be related to a piece of work they focused on whilst on their industrial placement year, or an extra-curricular project such as Formula Student.

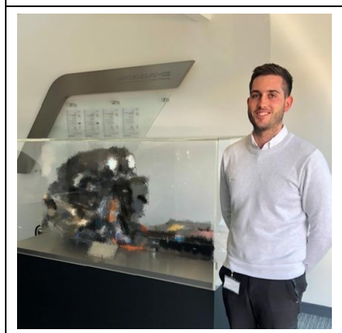
This piece of work is what the entire degree leads towards and is something every student can finish university feeling extremely proud of. The project is split up into an interim report, thesis and presentation. In "normal times" some students may also have the opportunity to undergo experimental research or manufacture prototypes.

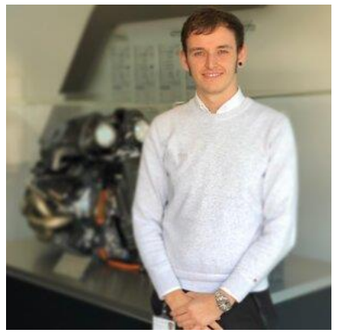
Both the group and final year projects develop lots of transferable skills such as:

- Conducting research
- Project management
- Time planning
- Self-motivation

The follow pages outline the project that our current cohort are undertaking.

PROJECTS

Image	Name	Title	Description	Image	Name	Title	Description
	George Poulter	Development of a usage monitoring method for a Formula One suspension system.	The aim of this thesis is to develop a usage monitoring methodology to implement on a Formula One suspension system. The purpose of this is to establish the remaining life of structures and to refine optimisation processes		Oliver Parnham	Combustion Emissions Analysis for Next-Generation Biofuels: A Numerical Approach.	The project aim is to provide an understanding and numerical predictions for combustion performance and emissions characteristics for diesel replacement biofuels in an effort to decarbonise diesel fuel usage in heavy duty Compression Ignition Engines
	Ashley Davison	The aerodynamic exploration and optimisation of the additional frontal protection on a single – seater formula car.	The key aim of this project is to analyse the airflow around the current halo on a single seater formula car, measure the impact it has on the key performance parameters and recommend the most suitable optimised design.		Solomon Smith	Altitude Compensation for a Bellmouth Rocket Nozzle.	This project aims to explore various methods of increasing a rocket nozzles expansion ratio as it ascends through the atmosphere, leading to increased efficiency and hence payload capabilities
	Sam Williams	Development of a composite gear.	The aim of this thesis is to develop a strategy for designing and manufacturing a composite gear for the use in electric racing.		Ciaran Berry	Development of an original road-bicycle Design using AM techniques, composites and advanced numerical analysis	The aim of this thesis is to develop a bicycle frame design that delivers the performance of high-end, mass-produced carbon fiber frames with the tailor-made nature of traditional techniques to optimise biomechanics performance
	Max Poulter	Lap Time Simulation of Motorsport Speed Events	The aim of this thesis is to develop a transient lap time simulation tool that will allow Sheffield Formula Racing, and a customer company, to make quantifiable justifications to concept decisions and vehicle set ups to a higher accuracy, detail and speed than currently available		Joshua Fletcher	Design & calibration of a low-cost Arduino based wireless DAQ device for a laboratory jet engine.	The aim of the project is to develop a data acquisition system and accompanying software using low-cost microcontroller hardware. The purpose of the DAQ system is to measure the performance of a small-scale jet engine used for undergraduate teaching.

	Edward Lavery Happe	Investigating thermal stratification in the hot plenum of the Korean Prototype Generation IV Sodium Cooled Fast Reactor during loss of flow.	The PGSFR is a new type of nuclear reactor currently being built in Korea, and my thesis aims to investigate the safety of its hot plenum during different shutdown scenarios. My main objective is to develop a transient CFD model to investigate thermal and flow characteristics of the sodium coolant during unprotected loss of flow.		Oliver Timms	Optimising the Aardvark Racing Ltd Chassis	This year, Aardvark Racing Limited have changed their powertrain to a 2.0l Ford Duratec, with the gearbox from a Fiesta ST150 and therefore altered their base chassis design to allow for a larger engine bay whilst maintaining the suspension and cockpit geometry. The chassis will be optimized using FEA within the boundary conditions specified by ARL, with an aim to maintain the torsional stiffness of smaller engine versions of the car, whilst reducing weight where possible. Analysis of previous work, including stress testing a previous chassis was done to provide a comparison and validate studies.
	James Wright	Optimising the Efficiency of Bolted Electrical Connections.	The aim is to investigate methods of improving the efficiency of bolted electrical connections via surface topography to directly result in an efficiency gain across a wider system.		Matthew Farrow	Investigation into drag reduction by fitting an aerodynamic shroud to a rowing oar.	The aim of this thesis is to investigate the relatively unexplored area of rowing aerodynamics, and develop a model which calculates average boat velocity depending on aerodynamic drag. The purpose is to develop a product which is cost and weight effective at reducing drag.
	Ben Clarke	The Design of Field Hockey Sticks to Optimise Impact Response.	In field hockey, a significant tension in making a stick is the balance between response and comfort. This project looks into the impact of nonlinearity in hockey sticks, and how this could be utilised to develop optimum characteristics.		Adam Laurence	A study in the thermal behaviour of a Formula Student EV battery pack.	Aiming to develop a model to evaluate the design of battery packs & cooling solutions in a FS EV setting.
	Wills Bloom	Analysis of the Material Design of the Front Clamshell of a Low Volume race car using an Aerodynamic Load Case	The aim of this project is to assess the effectiveness of the current basic material design/construction (fibreglass chopped matt manufactured using wet layup) of the front clamshell of Aardvarks Racing's latest race car dubbed the SP1. The assessment will involve a worst-case aerodynamic load case, simulated with CFD with an improved design as a stretch goal.		Jack Misweski Wall	An exploration into existing mesh refinement techniques and the downstream effects introduced when calculating the estimated fatigue-life of a cyclically loaded component.	The aim of this thesis is to investigate existing methods of mesh refinement, looking particularly at filleted regions and stress concentrations. A damage accumulation tool will be created as part of this project which will calculate the estimated fatigue-life of the component. The tool will highlight the effects that poor FEA has on the fatigue-life of a component and suggest reasons and methods for improvement.

TECHNICAL INSIGHT

AERODYNAMICS

TECHNICAL INSIGHT

AERODYNAMICS

What is an Aerodynamic Package?

An aerodynamics package is a system of components that is employed to a race car that aims to increase downforce by manipulating the airflow around it. This often includes a series of wings, fairings and bodywork panels.

Aerodynamic packages come in a range of sizes, complexity and shapes. These tend to be mostly dictated by the rules of the governing motorsport body. For example, in Formula Student our rear wing must span no wider than the inner surface of the wheels.

Why Aero?

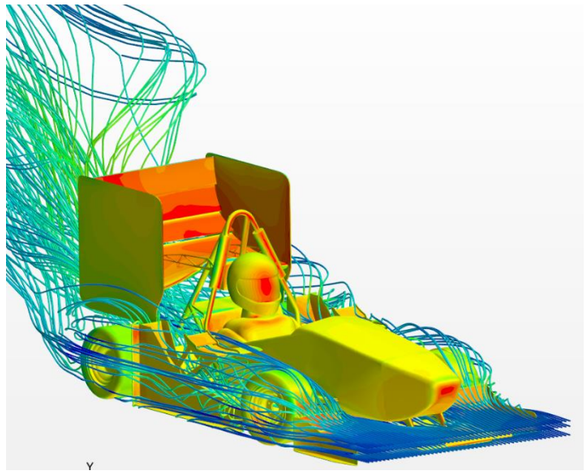
Almost all of the best performing Formula Student teams employ aerodynamic packages. The same can be said for highest level of motorsport such as Formula One.

The tyre is the only component that connects a race car to the ground and is the component what which all loads must be reacted through. The vertical load through the tyre determines the amount of a lateral load (or cornering force) that the tyre can produce. Simply put, the greater the vertical load, the quicker the car can turn. However, it is not as simple as making the car heavier, as this would in fact reduce the cornering capability because of the increased momentum of the vehicle.

It wasn't until the mid-1960's that engineers realised that we could utilise wings to produce downforce – i.e. more vertical load on our tyres without adding significant mass to the race car. By properly utilising aero-assisted tyre performance, dramatic improvements in cornering speeds were observed. During these early years, cornering accelerations grew from less than one gravitational acceleration (1g) to close to 4g.

Although our previous cars took advantage of aerodynamic design for systems such as the cooling ducts, SFR10 first used aerodynamics to improve the vehicles on-track grip. The package was comprised of front, side and rear wings, with a computational fluid dynamics (CFD) estimated lift and drag coefficient of -4.0 and 1.5 relatively

The more downforce on the car the better. However downforce tends to naturally result in more drag. As discussed in previous newsletters, SFR use lap time simulation tools to estimate the optimum downforce and drag for the car.



CFD

SFR use numerical methods to analyse our aerodynamic devices, namely CFD using star-CCM+. We currently use two different simulations to evaluate each design:

1. Straight line condition. This is used to observe drag whilst the car is travelling it is highest speed.
2. Cornering condition. We model the car going around a 18m radius corner at 15m/s with 2deg of body roll. This is simulation is used to focus more on increasing downforce in corners

Current Developments

Our current car is continuing with our proven architecture of front, side and rear wings. However, the team is currently focusing efforts on:

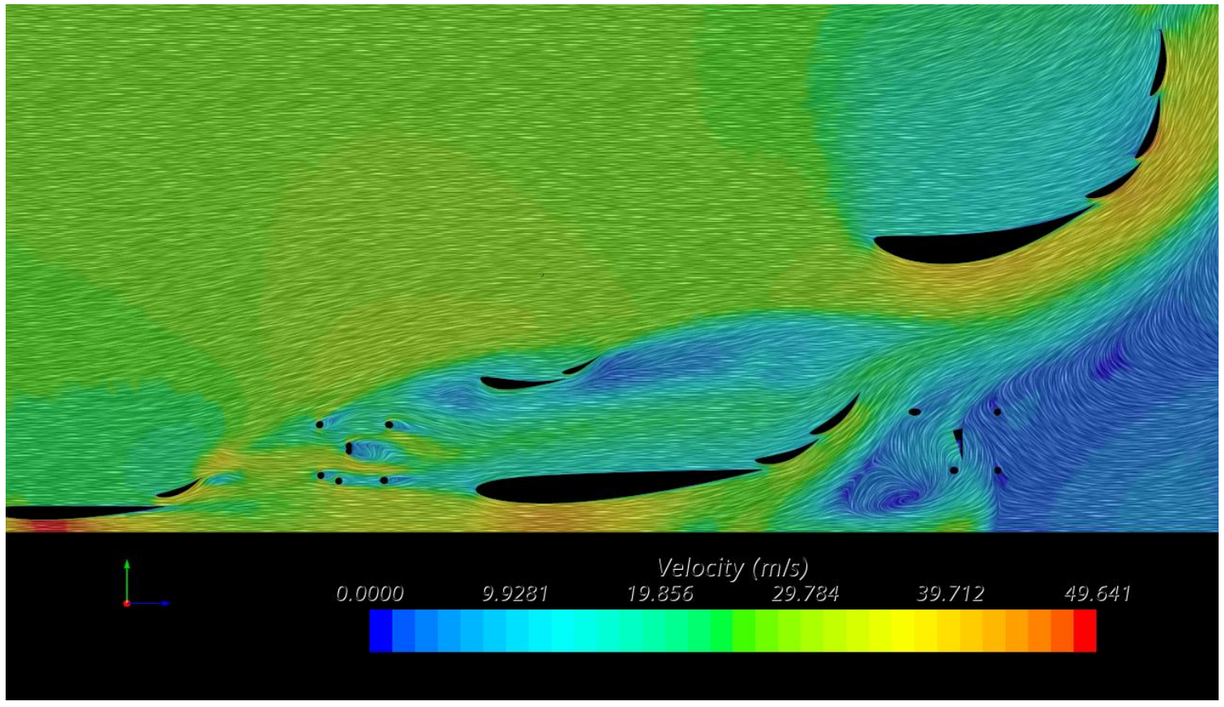
- Rear wing efficiency and reliability
- Canard to help control front wheel wake and condition it for the side wings
- Front wing
- Fuel tank "sloshing"
- Internal structure

Rear Wing Development

Our current mainplane is 'spooned' with a varying leading edge height across its span. This allows us to align the mainplane to the downwashing flow over the driver's helmet at the car centreline, whilst having a deeper rear wing for maximum downforce at the outboard ends. A leading edge suction peak was observed on the baseline design. The adverse pressure gradient produced by this leads to boundary layer growth that can lead to the wing stalling as the car pitches and rolls through corners. The sudden loss of downforce when the wing stall will not only harm the car's lap time but also driver confidence. The latest design removes this suction peak and promises to give us a more drivable car with consistent downforce.

Structure Development

One element that was compromised in SFR10's design was the stiffness of our front and rear wings. SFR11 aimed at increasing this through better finite element analysis (FEA) simulations. Rohacell has been added to some wing elements which provides a lightweight solution as well as increasing stiffness compared to the previous 'traditional' rib and spar design.



SPONSOR ARTICLE

Parkwood Karting

Parkwood Karting is a Sheffield – based outdoor ‘arrive and drive’ karting circuit. Parkwood have supported Sheffield Formula Racing for many years now, with the 470 metre circuit providing the team with a prime facility for developing and testing our cars over the years.

The advantages of using Parkwood as our priority testing facility is because of its close distance to our university facilities, the track’s twisty nature which is very useful for vehicle dynamic testing, and finally the warm welcoming we receive from Parkwood themselves.

Furthermore, Parkwood Karting have been the host for many of Sheffield Formula Racing’s social events through the years. The team have always enjoyed taking a break from university and the Formula Student project itself to spend an afternoon karting against each other and competing for that top podium spot.

The major tests that frequently take place at Parkwood include the checking for oil leaks, efficient engine start-ups and smooth running of the engine. Recent tests that took place prior to the Covid-19 pandemic included the testing of the Proshift to replace the manual gear shifter and the testing of the new fuel pump.

Other activities that the team proceed with at Parkwood Karting include driver testing which helps us choose a fast team member for the Formula Student competition. In addition, one of our team members is currently working on a lap time simulation for the Parkwood circuit using data from our most recent car, to help us better understand areas of improvement needed.

ALUMNI ARTICLE

THOMAS BLOOMFIELD

COURSE:
MEng Mechanical Engineering

DATE JOINED:
September 2011

ROLES HELD:
Powertrain Engineer (2011-2013), Reserve Driver (2012-2013), First Year Integration Officer and Engine Team Leader (2013-2014), Team Principal and Driver (2014-2015)

CURRENT POSITION:
Chief Operating Officer – Itch Innovation

Thomas Bloomfield started studying Mechanical Engineering at the University of Sheffield in 2011 and joined the team at the same time. Although Thomas was not a huge follower of Formula One, he wanted to join the team as he was enamoured with the camaraderie of working as a team and found the idea of designing a race car and existing way to support this.

Thomas held a variety of roles whilst we was with us, ranging from a Powertrain Engineer in his first year, First Year Integration Officer (ensuring the smooth integration of new members) in his second year, Engine Team Leader in his third year and namely Team Principal in his final year of study. He was also lucky enough to drive SFR06 at Silverstone Race Circuit in 2015.

What Skills did you develop with us?

Thomas believed that his “computer aided design (CAD) skills were learned and certainly well-practiced (whilst) designing the car”. Formula Student is also a great way of supporting academic studies with practical work. Thomas explained to use that being a powertrain engineer allowed him to gain a great understanding of the working of an engine, in particular the clutch; after having to rebuild the engine when he shattered the clutch in testing. Formula Student also enabled Thomas to get hands on with manufacturing techniques such as composite layup and welding – something that you wouldn’t typically get whilst studying at University.

However, Thomas thought that “probably the most important skill was rapid problem solving”. He elaborated on many times during scrutineering you need a fast solution, when sometimes you have compromise from your optimum design and find a resolution that is achievable to get back on track as quickly as possible. This problem solving key is something that all engineers must have, despite their discipline.

Where are you now?

Once Thomas graduated he was offered the exciting opportunity to join a new innovative engineering solutions business in Sheffield (Metlase), which, at the time, had only 6 employees. Thomas was the Business Development Engineer at Metlase and was able to see this company grow - which now has over 30 employees. Metlase are true believers in the development of young people and therefore very supportive of sponsoring SFR that the teams link with Thomas. As covered in our December issue, the sponsorship has led to a number of placement and graduate offer within the team.

Thomas has recently become Chief Operating Officer at Itch Innovation. Itch is a group of young companies which like to focus heavily on inventions, innovations and engineering within their respective businesses. Thomas’ new role is very diverse. His main focus is bringing in investment into their latest venture, FYOUS, which is aiming to revolutionise the footwear industry by creating a process that enables an on demand model of perfectly fitting custom shoes.

“SFR gave me a strong footing with Leadership experience. I have done a few commercial roles since (SFR) that helped me gain the rest of the skills needed (to become Chief Operating Officer)”

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