Optimisation & Comparative Analysis of F1 2026 Front Wing Designs

Author: Toby Mason

Date: 16/07/2025

Use document F1 2026 Front Wing Report for project information if not mentioned in this report assume it is the same

1. List of Figures

2. Introduction

2.1 Purpose of the Study

This project aims to further my understanding of the aerodynamic performance of F1 front wings and optimise my designs through studying simulation results and understanding where I can improve my model for better results. I seek to identify the most effective design in terms of lift and drag coefficients. This new design uses the original design 2 as the base.

2.2 Scope of the Report

The report covers the modelling and analysis of my optimised front wing design. The study follows FIA guidelines and utilises CFD simulations to evaluate the aerodynamic performance of the design.

3. Changes made to the model

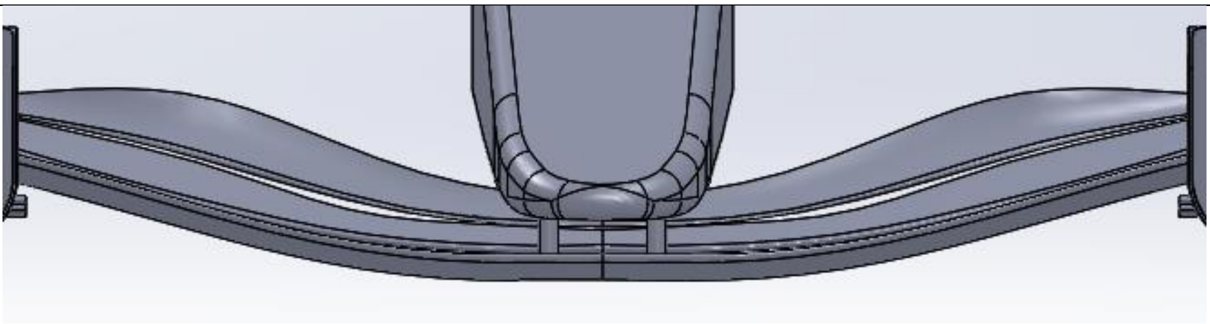

Figure 1: New flap geometry

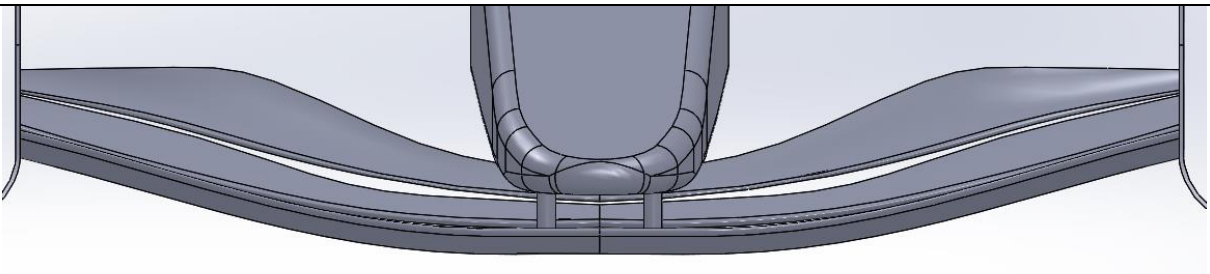

Figure 2: Old flap geometry

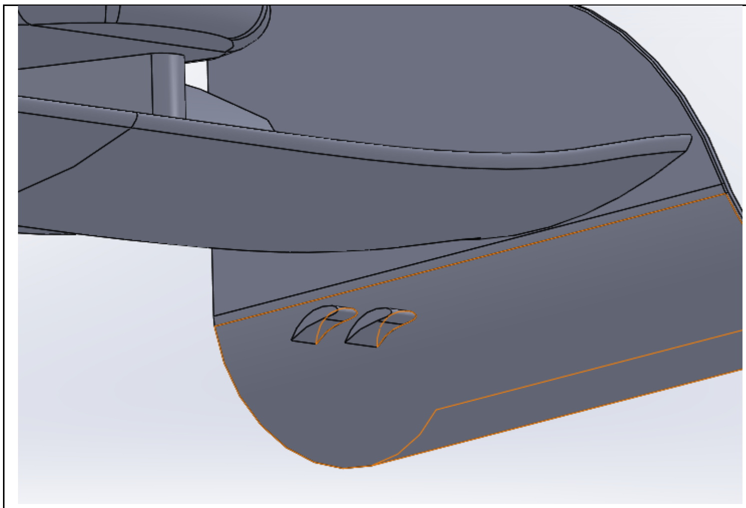

Figure 3: Added strakes

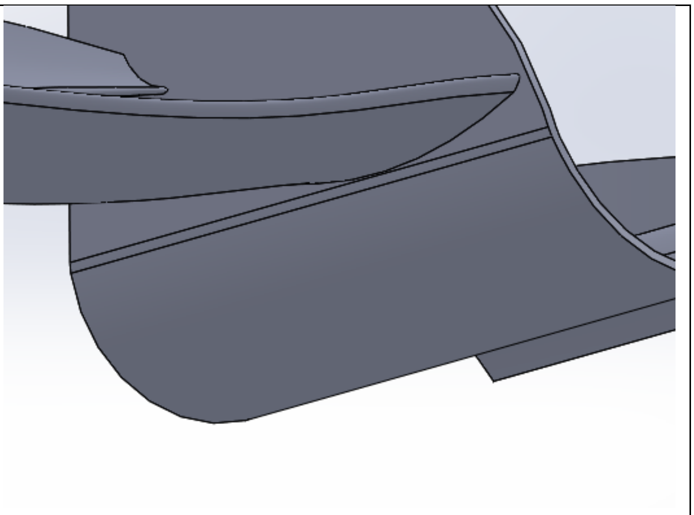

Figure 4: Old geometry

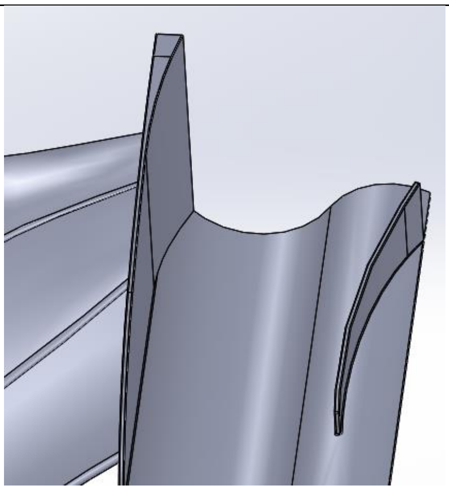

Figure 5: New endplate geometry

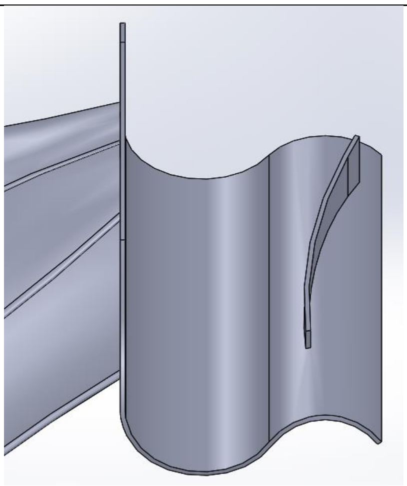

Figure 6: Old endplate geometry

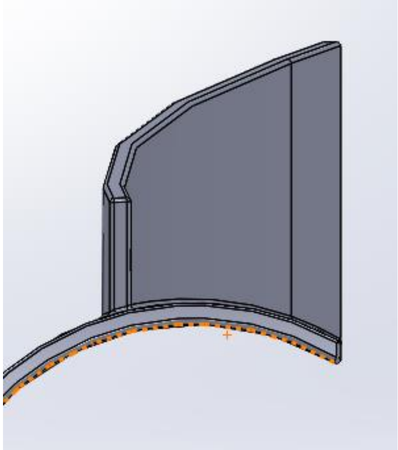

Figure 7: New endplate geometry

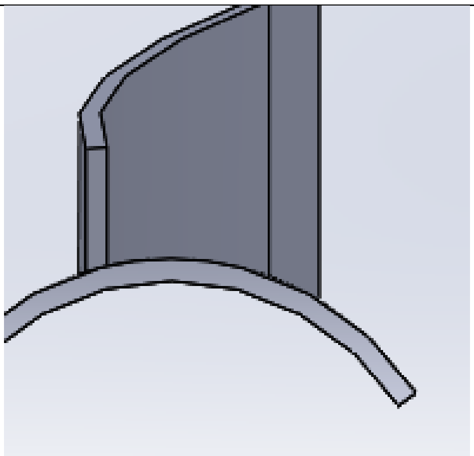

Figure 8: Old endplate geometry

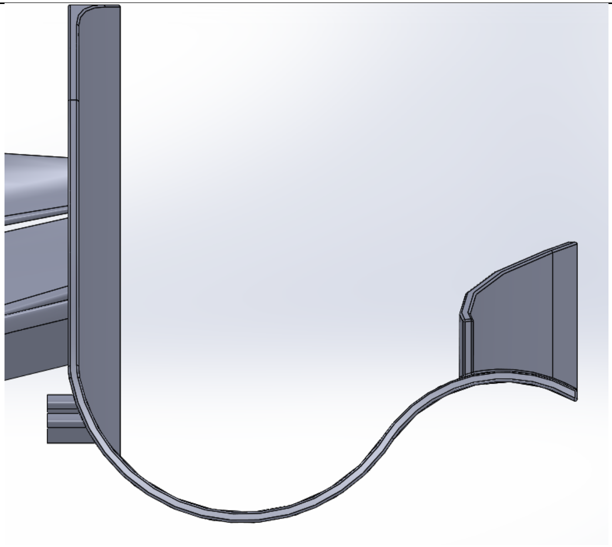

Figure 9: New fillets on the end plate

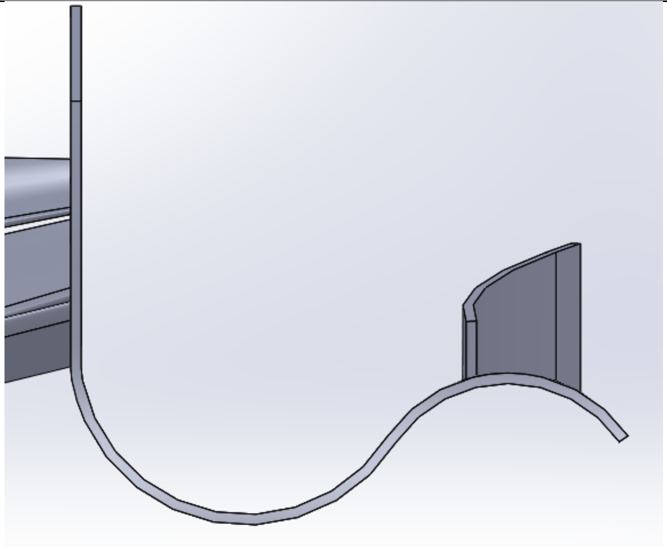

Figure 10: Old end plate

3.1 Geometry changes

This report outlines a series of aerodynamic refinements made to a 2026 Formula 1 front wing concept. The modifications were guided by principles of aerodynamic efficiency, with the goal of enhancing front-end downforce, and improving downstream airflow to critical components such as the floor and bargeboards. The following five key design changes were implemented and evaluated:

3.1.1 Decreased Flap Pitch

Modification:
The flap elements were reprofiled with a reduced angle of attack compared to the original geometry, resulting in a flatter and more aerodynamically efficient configuration.

Aerodynamic Rationale:

- **Drag Reduction:** A lower flap pitch significantly reduces both induced and form drag, particularly at high speeds. This contributes to improved straight-line performance and overall aerodynamic efficiency crucial for circuits with long straights or DRS zones.
- **Flow Stability:** The flatter flap profile promotes more stable and attached airflow, reducing the likelihood of flow separation and turbulent wake formation. This enhances the predictability of the front wing's aerodynamic behaviour across a range of yaw angles and ride heights.
- **Vortex Management:** While the intensity of tip vortices is reduced, this can be advantageous in minimising unwanted vortex interference with downstream components. A cleaner vortex structure can lead to less turbulent interaction with the floor and bargeboards, improving their effectiveness.
- **Balance Optimisation:** This change supports a more balanced aerodynamic platform, especially when paired with a high-efficiency rear wing or underfloor. It allows for finer tuning of the car's aero balance to suit specific track characteristics or driver preferences.

3.1.2 Addition of Strakes on the Inner Face of the Endplate

Modification:
Vertical strakes were added to the inner surface of the endplate.

Aerodynamic Rationale:

- **Flow Conditioning:** These strakes act as flow straighteners, guiding and energising the airflow passing through the inboard section of the wing.
- **Vortex Control:** They help generate controlled vortices that can be used to manage the turbulent wake from the front tires, reducing its impact on the underfloor and sidepod inlets.
- **Drag Reduction:** By stabilising the airflow and reducing separation, strakes can contribute to a net reduction in pressure drag.

3.1.3 Outward-Angled Endplate

Modification:
The endplate was canted outward slightly relative to the car’s longitudinal axis.

Aerodynamic Rationale:

- **Outwash Enhancement:** This geometry promotes lateral airflow (outwash) around the front tires, helping to divert turbulent wake away from sensitive downstream components.
- **Tire Wake Management:** Improved outwash reduces the size and intensity of the tire wake, enhancing the performance of the floor and diffuser.
- **Drag and Stability:** While the outward angle may slightly increase frontal area, the net aerodynamic benefit from improved wake control typically outweighs this cost.

3.1.4 Redesigned Endplate Geometry

Modification:
The endplate was reshaped, involving changes in leading/trailing edge profiles.

Aerodynamic Rationale:

- **Vortex Optimization:** The new geometry likely refines the generation and trajectory of key vortices, such as the Y250 vortex, which plays a critical role in energising the floor.
- **Flow Attachment:** A more aerodynamically contoured endplate improves flow attachment and reduces separation, especially under yawed conditions.
- **Downstream Synergy:** Enhancing the endplate’s aerodynamic behaviour improves the consistency and effectiveness of the entire front aero package.

3.1.5 Fillets on the Front Faces of the Endplate

Modification:
Smooth fillets were added to the leading edges of the endplate.

Aerodynamic Rationale:

- **Flow Smoothing:** Fillets reduce sharp transitions, minimising local flow separation and improving boundary layer behaviour.
- **Drag Reduction:** By smoothing the airflow path, fillets help reduce form drag and improve the aerodynamic cleanliness of the endplate.
- **Vortex Stability:** The more gradual curvature can lead to more stable and predictable vortex formation, enhancing overall flow control.

3.2 Conclusion

The cumulative effect of these modifications is a front wing that is more aerodynamically efficient, with improved downforce generation, better tire wake management, and enhanced flow quality to downstream components. These changes align with modern F1 aerodynamic strategies and are expected to yield measurable performance gains in both cornering and straight-line conditions.

4. Methodology

4.1 Design Process

The design process for the front wing model was guided by the FIA 2026 Formula 1 Technical Regulations (Issue 8 - 2024-06-24) [4]. These regulations provided detailed guidelines and rules for the design. The maximum length of the front wing was set at 1800mm. SolidWorks 2017 was used to create the 3D model of the front wing design.

4.2 CFD Simulation Setup

1. **Geometry Import**: The front wing geometry was imported into the simulation.
2. **Enclosure Creation**: An enclosure was created with a ride height of 35mm (0.03m). Can be seen in figure 3.
3. **Boolean Subtraction**: A Boolean subtraction operation was performed, with the enclosure as the target body and the front wing part as the tool body.
4. **Mesh Creation**: A mesh was generated with an element size of 1000mm, I also set up a face sizing on the external faces (e.g. walls) of 2000mm. This resulted in 102783 nodes. The maximum number of nodes was limited to 105,000 due to the constraints of the student version of ANSYS.
5. **Named Selections**: Named selections were added to ensure zone names matched.
6. **Mesh Check**: The mesh was checked for accuracy and consistency.
7. **Model Setup**: The k-epsilon model was set to realizable.
8. **Materials**: Default materials were set to air and aluminium.
9. **Boundary Conditions**: Inlet velocity was set at 80 m/s. Seen in figure 5.
10. **Reference Values**: Reference values were computed from the inlet and the solid body.
11. **Methods**: Spatial discretization was set to second order upwind for all methods.
12. **Report Definitions**: Lift and drag report definitions were created.
13. **Initialization**: Hybrid initialization was performed.
14. **Iterations**: 500 iterations were run.
15. **Contour Visualization**: Pressure contours were created on the body with 15 contours.
16. **Streamlines**: Streamlines were generated from the inlet to visualize air velocity, using 1000 lines.

Note**:** If not mentioned leave as default

5. Results

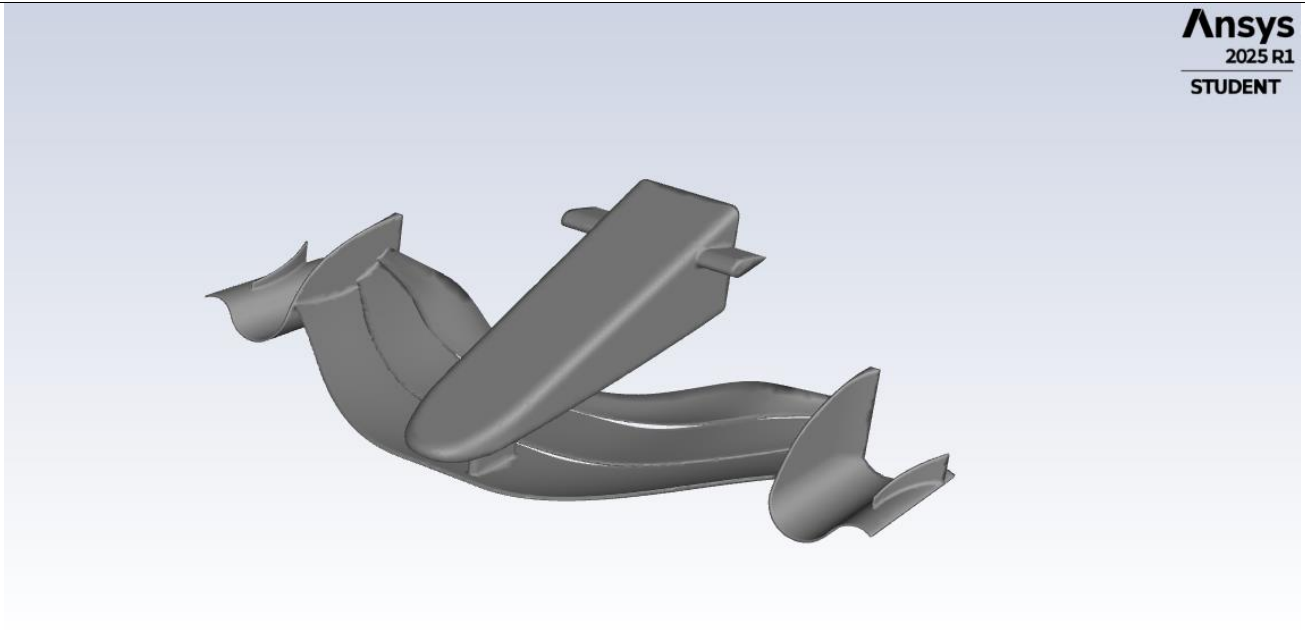

Figure 11: Model of my optimised front wing

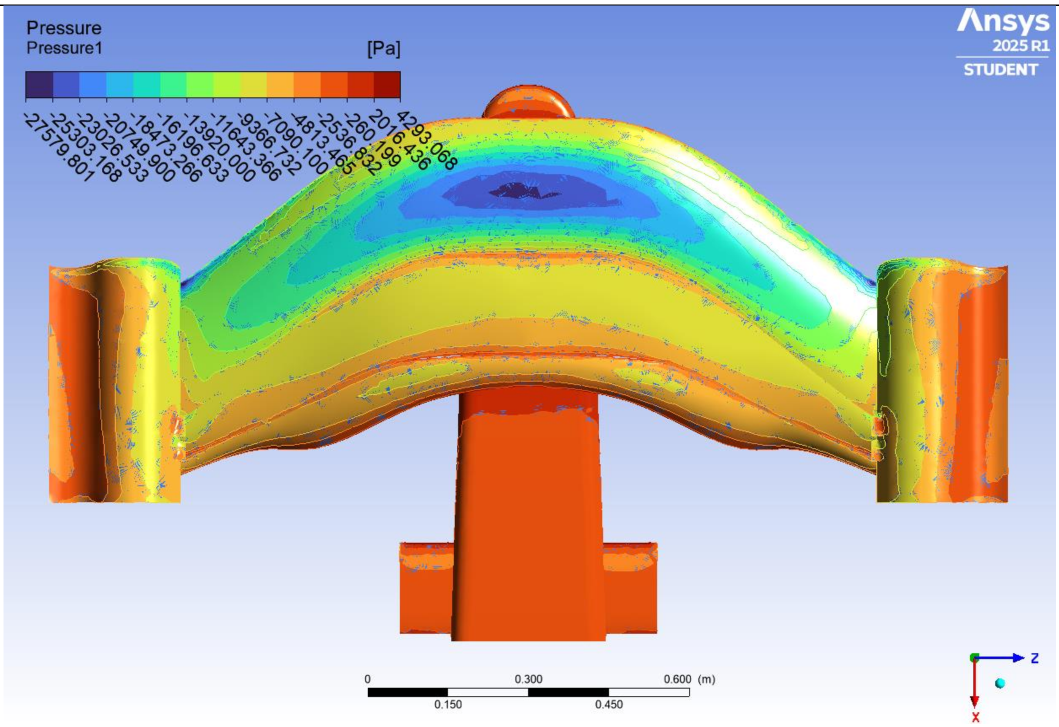

Figure 12: Pressure contour on front wing (under side)

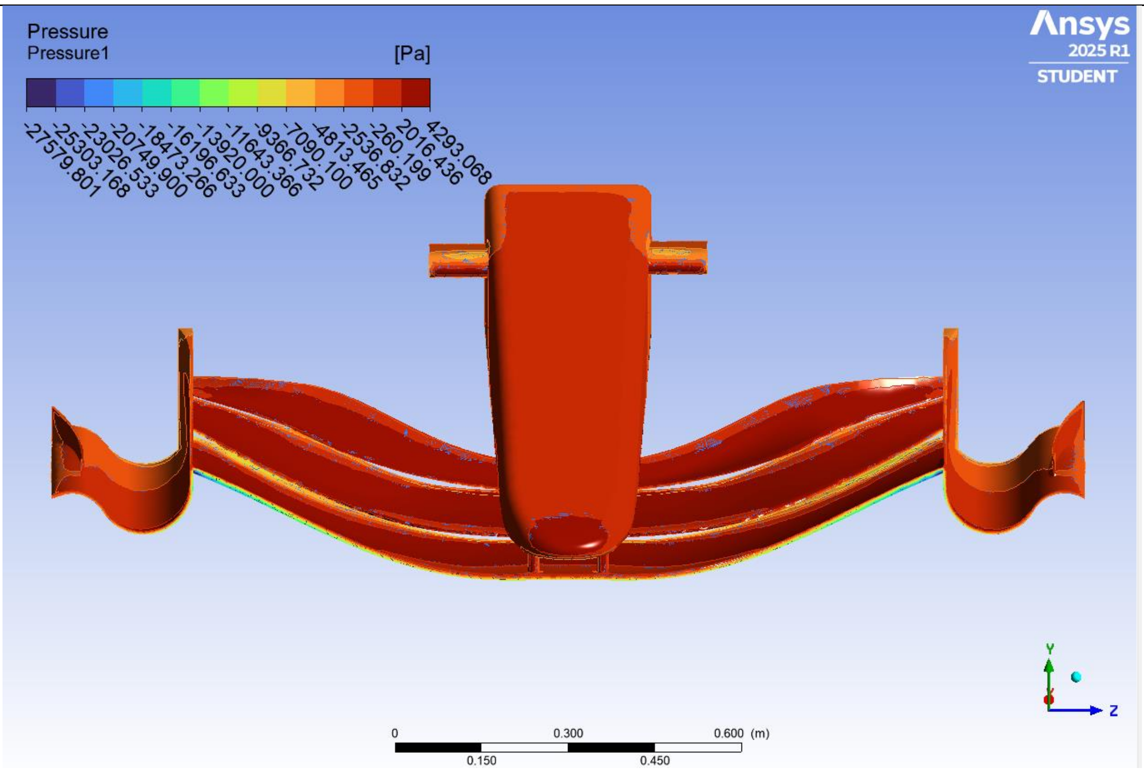

Figure 13: Pressure contour on front wing (top side)

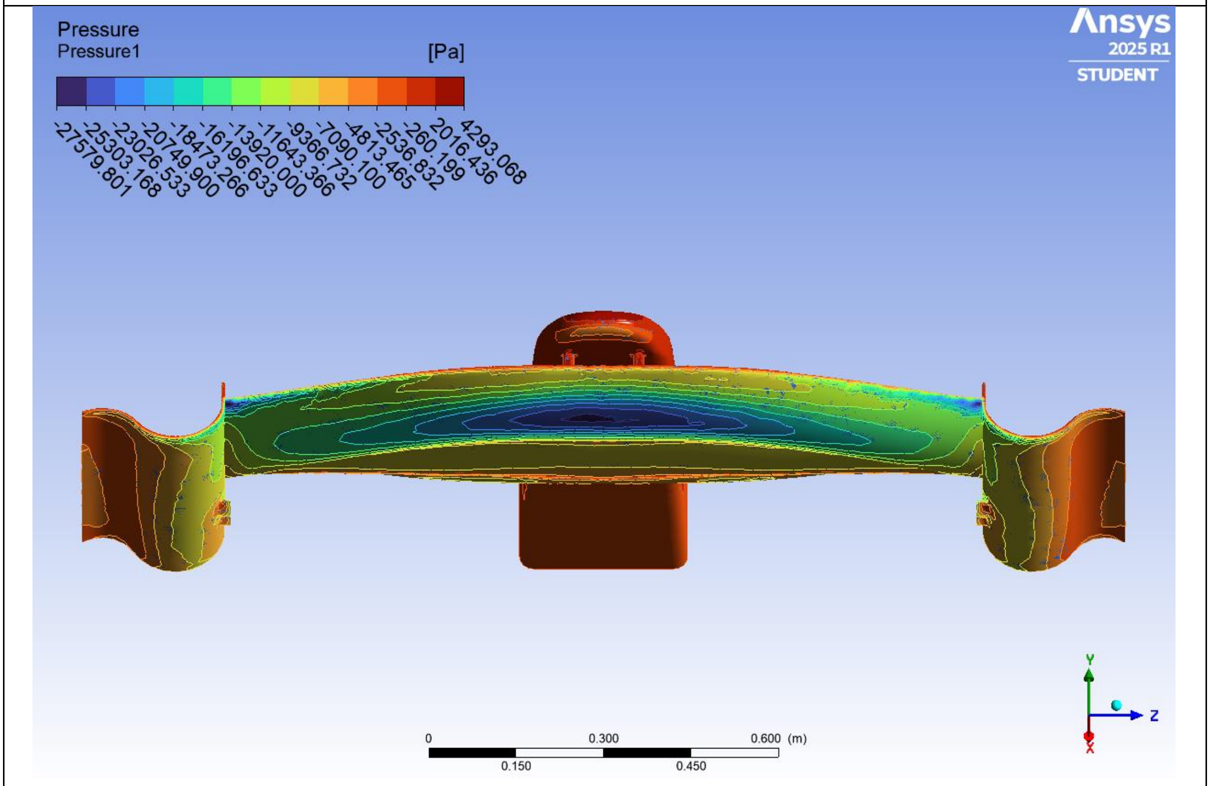

Figure 14: Pressure contour on front wing (front)

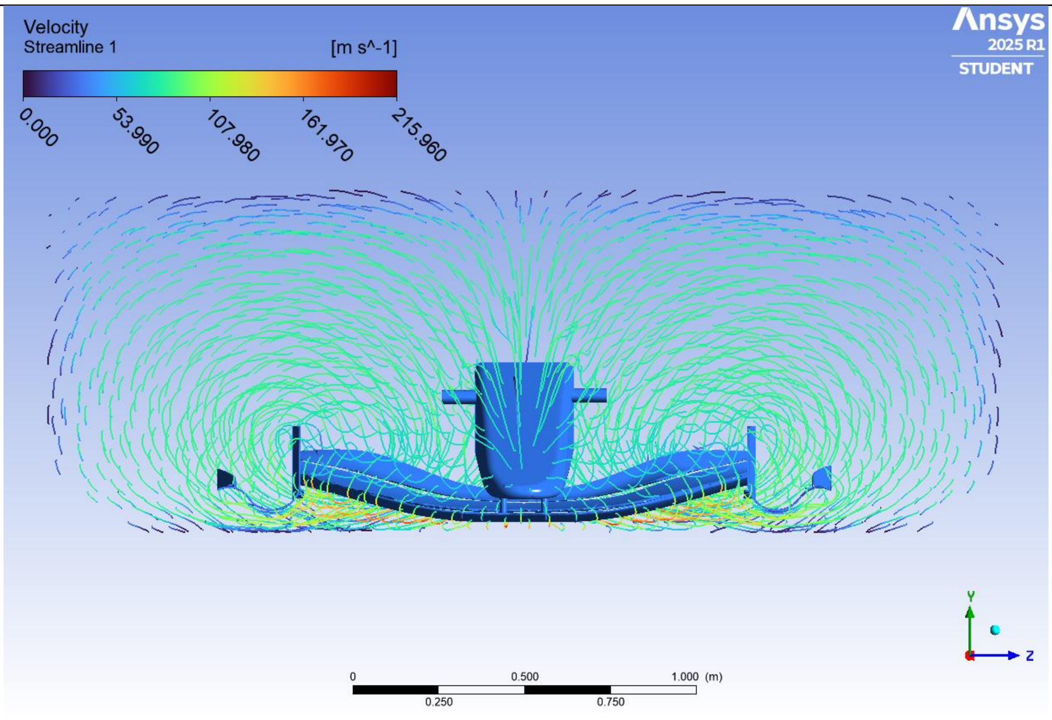

Figure 15: Velocity of surrounding air (head on view)

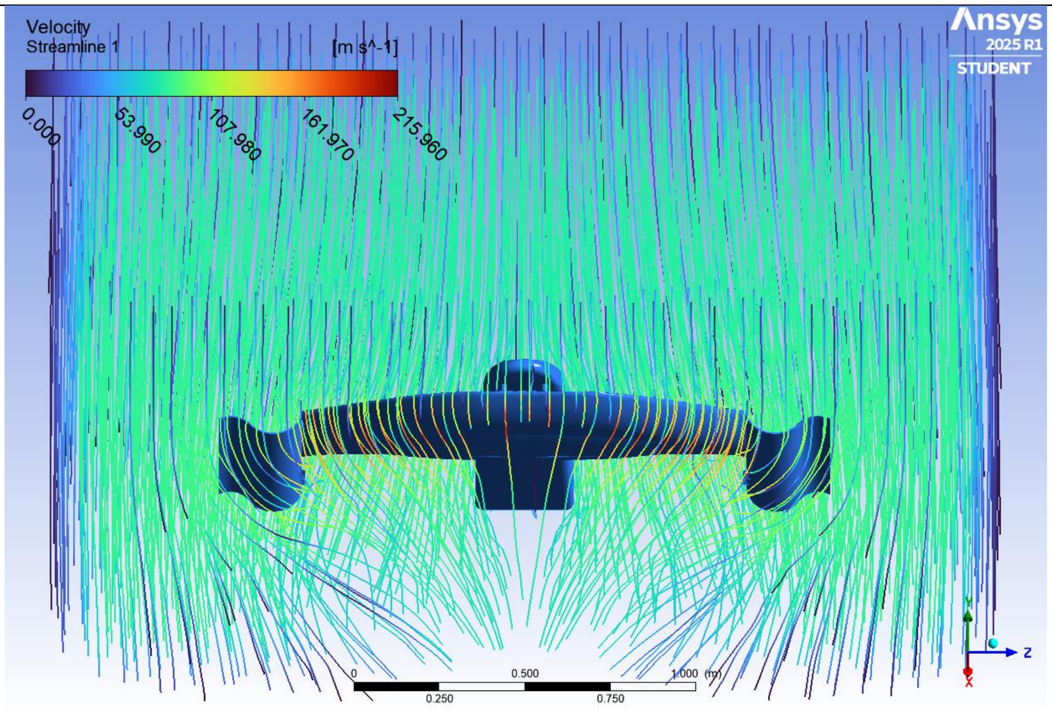

Figure 16: Velocity of surrounding air (under side view)

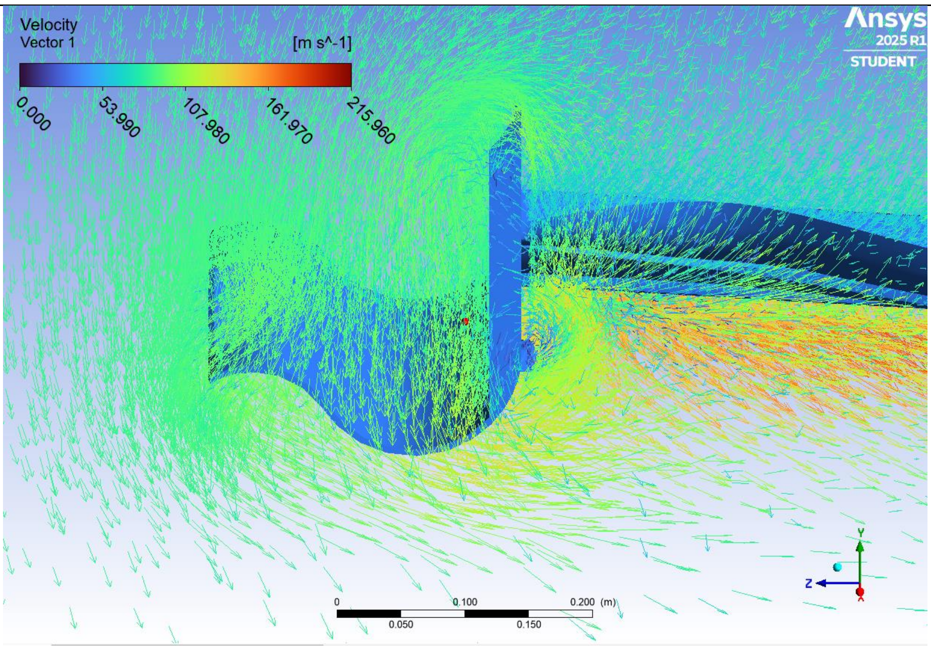

Figure 17: Velocity of air coming off end plate and strakes

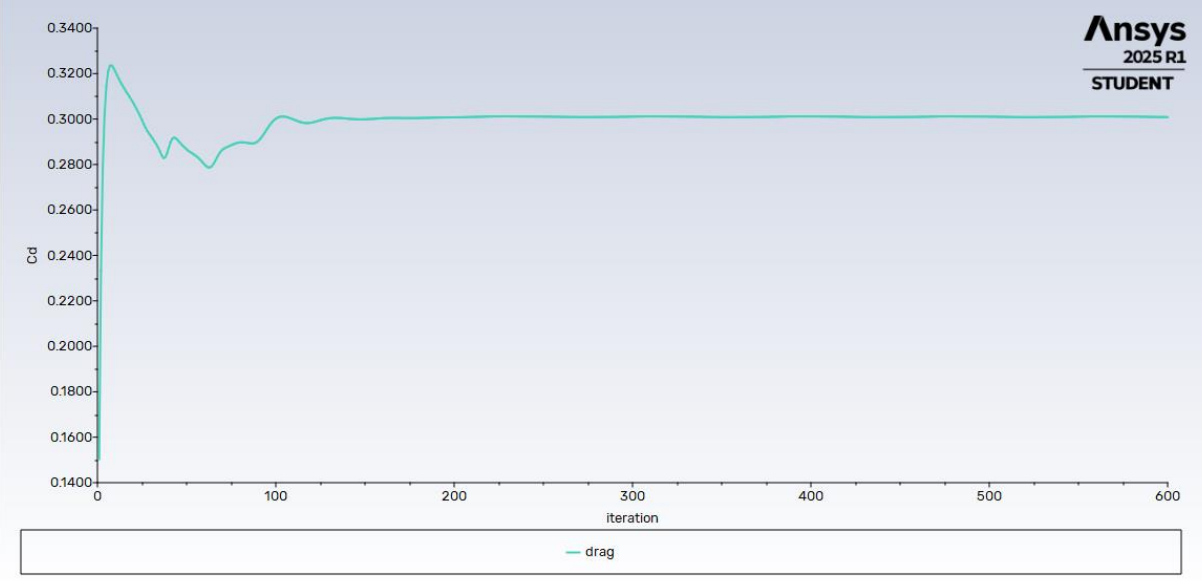

Figure 18: Drag Coefficient Result

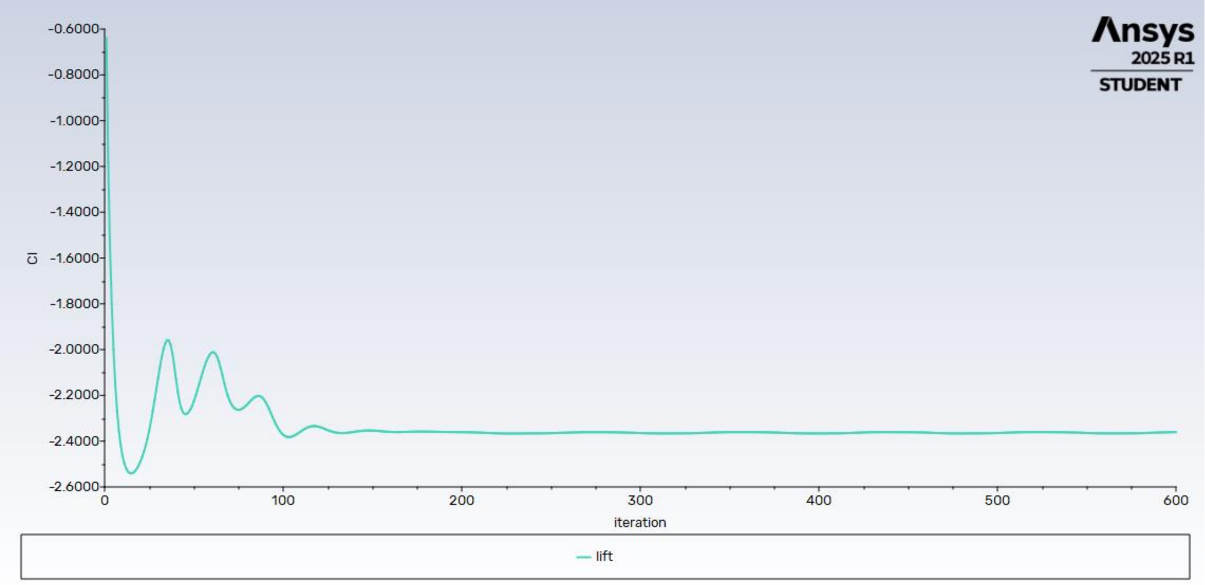

Figure 19: Lift Coefficient Result

6. Discussion

6.1 Overview

The aerodynamic performance of the 2026 Formula 1 front wing was evaluated using CFD simulations in ANSYS Student. The analysis focused on pressure distribution, airflow velocity, vortex formation, and aerodynamic coefficients. The results demonstrate a well-optimised design that aligns with the high-performance demands of modern F1 aerodynamics.

Design	Drag Coeff	Lift Coeff
Optimised model	0.3	-2.36

6.2 Pressure Contour Analysis

Figures 12-14 illustrate the pressure distribution across the front wing surface. The pressure contours reveal a clear pressure differential between the upper and lower surfaces of the wing elements:

- **High-pressure zones** (red regions) are concentrated on the lower and top surfaces of the wing elements, particularly near the leading edge. This is expected, as these surfaces face the oncoming airflow directly.
- **Low-pressure zones** (blue regions) dominate the under surfaces, especially over the curved profiles of the flaps. This pressure drop is a result of accelerated airflow, consistent with Bernoulli's principle.

This pressure differential is critical for generating downforce, which presses the car onto the track, improving grip and cornering performance. The smooth gradient transitions and absence of abrupt pressure spikes indicate a well-managed flow with minimal separation.

6.3 Velocity Field and Vortex Behaviour

Figures 15–17 present the velocity streamlines and vector fields around the front wing:

- The **velocity magnitude** ranges from 0 to approximately **216 m/s**, with the highest velocities observed over the under surfaces of the wing elements. This confirms effective flow acceleration and suction generation.
- **Streamline curvature** and **vector field patterns** reveal the formation of coherent vortices, particularly near the endplates and flap tips. These vortices are essential in managing the wake and directing airflow around the front tires, reducing turbulence and drag downstream.
- The **vortex structures** are stable and well-formed, suggesting that the wing design effectively controls flow separation and maintains attached flow even at high speeds.

These characteristics are vital in F1, where managing turbulent wake and tire wake interference can significantly impact overall aerodynamic efficiency.

6.4 Aerodynamic Coefficients

The simulation yielded the following aerodynamic coefficients:

- **Drag Coefficient (Cd): 0.30**
- **Lift Coefficient (Cl): -2.36**

These values are highly favourable for a front wing in a Formula 1 application:

- A **Cd of 0.30** indicates relatively low aerodynamic resistance, which is crucial for maintaining high straight-line speeds without excessive energy loss.
- A **Cl of -2.36** signifies substantial downforce generation, which is essential for maximizing tire contact and mechanical grip during high-speed cornering and braking.

The high downforce-to-drag ratio reflects a well-balanced design that prioritizes cornering performance without compromising too much on straight-line efficiency.

6.5 Application Relevance and Design Implications

In the context of a 2026 F1 front wing, these results are highly encouraging:

- The **pressure and velocity profiles** confirm that the wing effectively manipulates airflow to generate downforce and manage wake.
- The **vortex structures** are indicative of advanced aerodynamic shaping, likely incorporating features such as vortex generators and optimized endplates.
- The **aerodynamic coefficients** align with modern F1 design targets, where maximizing downforce while minimizing drag is a constant trade-off.

These findings suggest that the front wing design is not only aerodynamically efficient but also strategically tuned for competitive performance in the 2026 F1 regulations, which emphasize both sustainability and aerodynamic refinement.

7. Conclusion

This study successfully explored and optimised the aerodynamic performance of a 2026 Formula 1 front wing through a structured design and simulation process. Guided by FIA regulations and grounded in aerodynamic theory, the project implemented a series of targeted geometric modifications aimed at enhancing downforce generation, reducing drag, and improving downstream airflow quality.

The final optimised design, derived from iterative refinements to the original concept, demonstrated a significant improvement in aerodynamic efficiency. Key changes—including reduced flap pitch, the addition of inner endplate strakes, outward-angled and reshaped endplates, and the introduction of fillets, collectively contributed to a more stable and effective aerodynamic profile. These modifications were validated through CFD simulations, which revealed coherent vortex structures, smooth pressure gradients, and high-velocity flow regions indicative of strong suction and flow attachment.

Quantitatively, the optimised model achieved a drag coefficient of 0.30 and a lift coefficient of -2.36. These values reflect a well-balanced aerodynamic package, capable of delivering substantial downforce without incurring excessive drag penalties, an essential trade-off in modern Formula 1 design. The pressure and velocity field analyses further confirmed the wing's ability to manage airflow efficiently, reduce tire wake interference, and maintain flow stability across a range of operating conditions.

In conclusion, the optimised front wing design not only meets the aerodynamic demands of the 2026 Formula 1 regulations but also exemplifies the application of advanced aerodynamic principles in motorsport engineering. The results underscore the importance of detailed geometric tuning and simulation-driven development in achieving high-performance aerodynamic solutions. Future work could involve full-car simulations and wind tunnel validation to further refine the design and assess its integration with other aerodynamic components.

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