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Title: Development of a prototype spoiler for effective braking of a racing motorcycle, utilizing active aerodynamics

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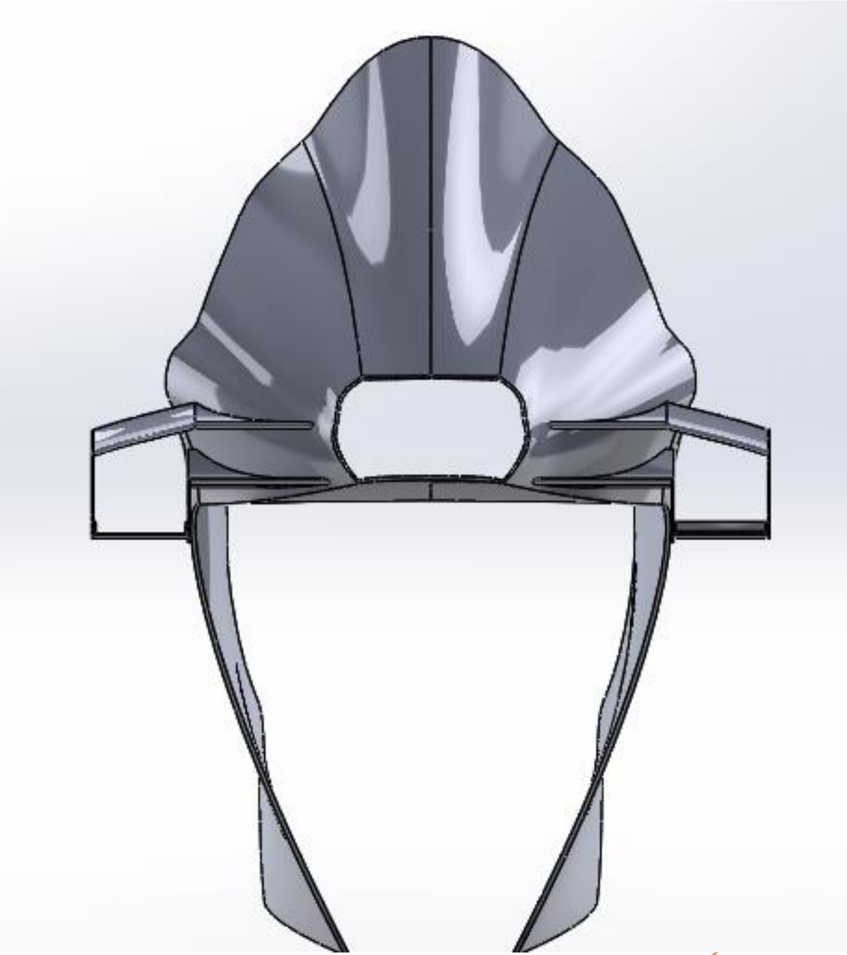


Introduction

This investigation highlights the importance of aerodynamic modifications to improve performance during braking and direction changes most crucial aspects in motorcycle competitions.

The wings in MotoGP increase drag and lift force according to the lean angle, fundamental to understanding their impact on the aerodynamics of competition motorcycles.

History in motorcycles aerodynamics

- Previous studies of bird and fish.
- The end of World War II in 1945 saw the beginning of the space race between the United States and the Soviet Union from 1957 to 1975.
- limiting experimental design variations on a large scale.
- Wind tunnelsleading to significant advancements in automotive aerodynamics in 1973.
- CFD.
- Since 2015 motorcycles have been equipped with "winglets.
- Van Dijck and Joao Gaspar Cardoso, have demonstrated and evaluated the aerodynamic forces on a road motorcycle modified for high-speed competitions.
- Active Aerodynamics.

Mathematical and physical methods

In the way of design an spoiler its important to know some physical and mathematical methods to understand the correct way of function and not design something dangerous to the racers.

Some of them are:

Bernoulli equation

Downforce

Reynolds number

Drag

Fluid mechanics

Lift

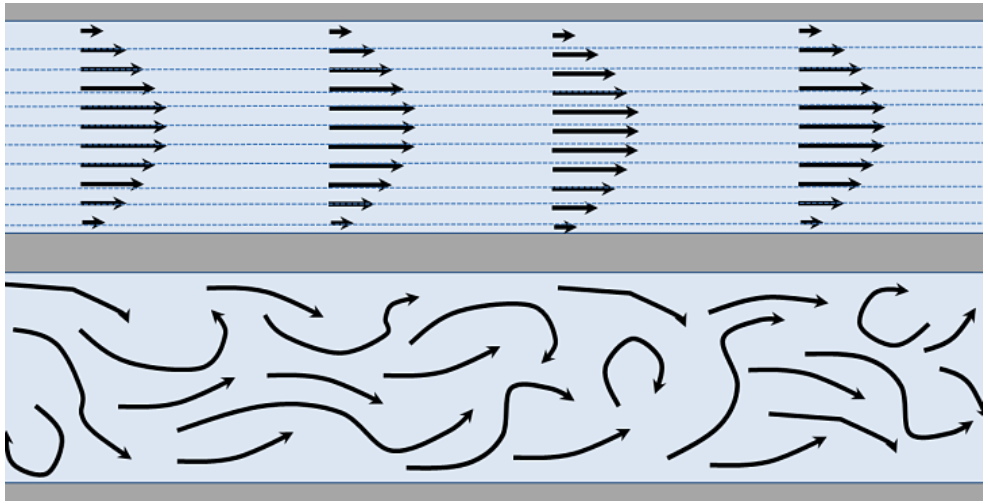
Types of flow

$$P1 + \frac{1}{2p} v1^2 = P2 + \frac{1}{2p} v2^2$$

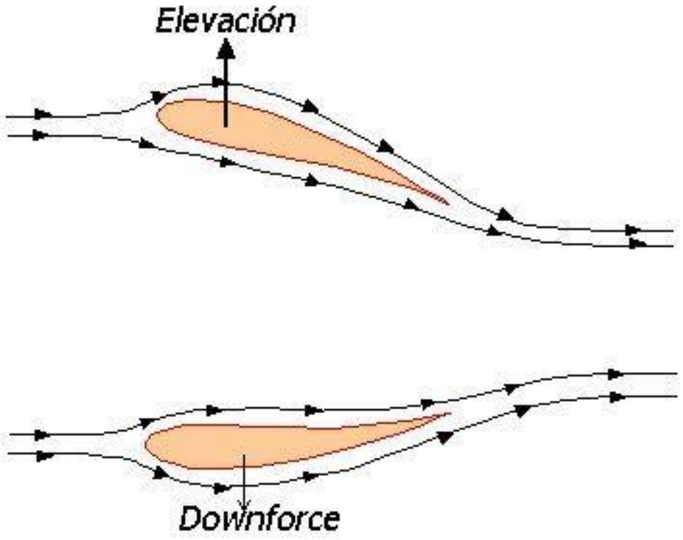
$$F = 0.5 * D * Cl * A * V^2$$

Mathematical and physical methods

Types of flow



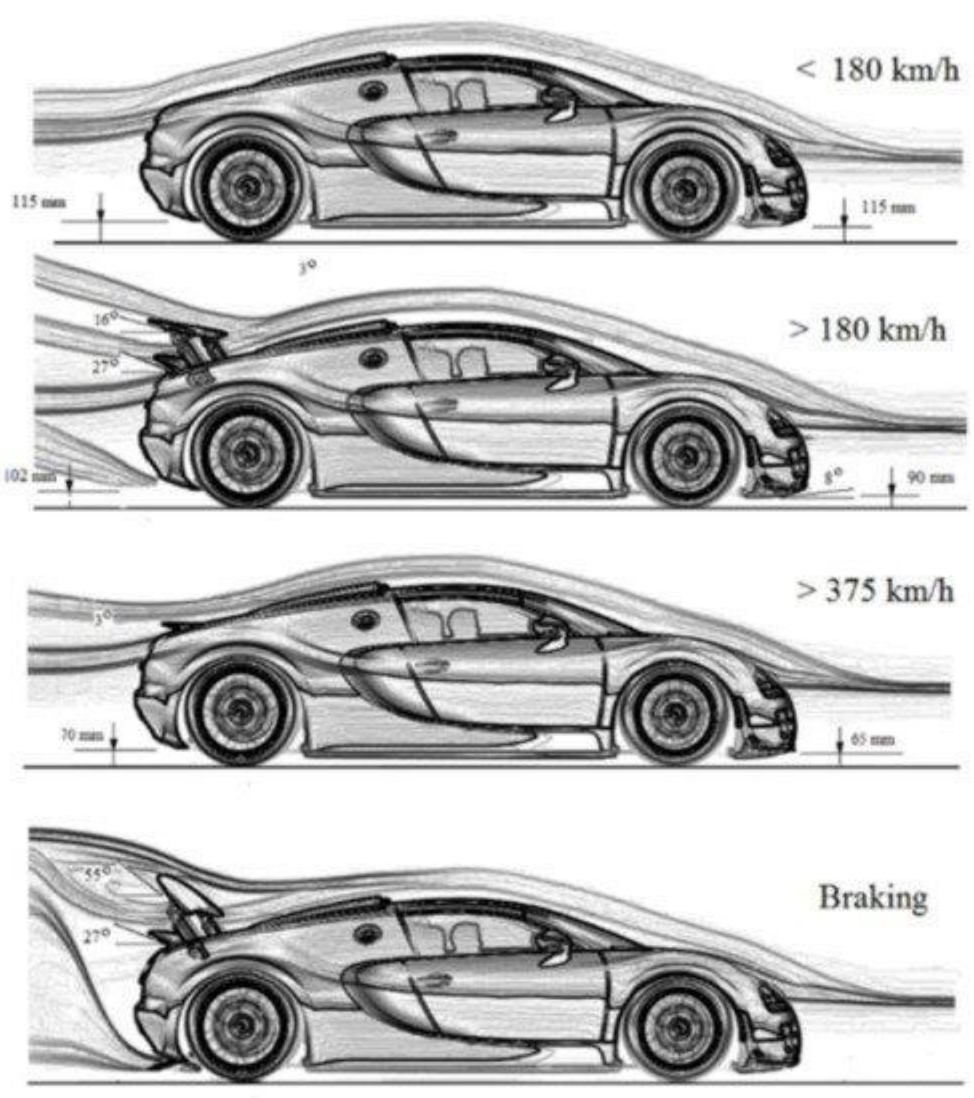
Lift and downforce



Aerodynamics and active aerodynamics.

- **Aerodynamic:** specializes in studying the principles and laws governing interactions between air and objects.

- **Active aerodynamics:** in the context of vehicles, involves the ability to generate and modify aerodynamic forces on a surface in response to vehicle movement

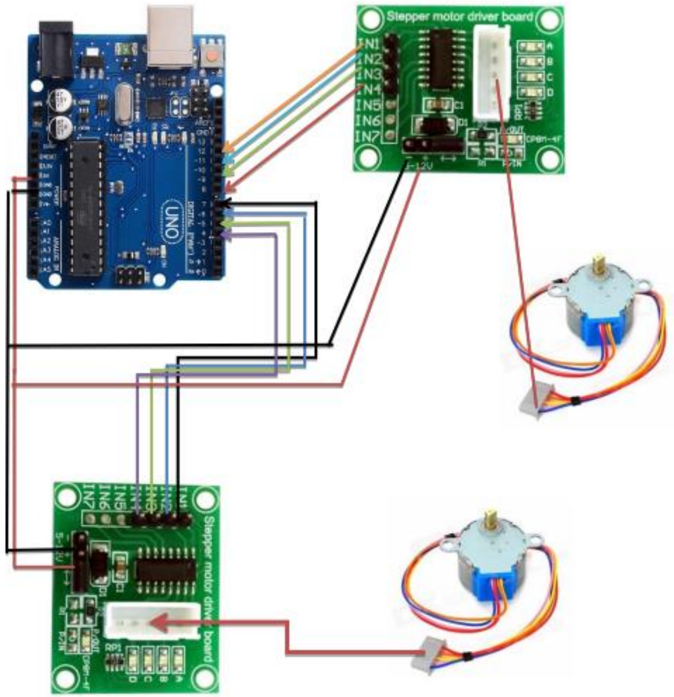


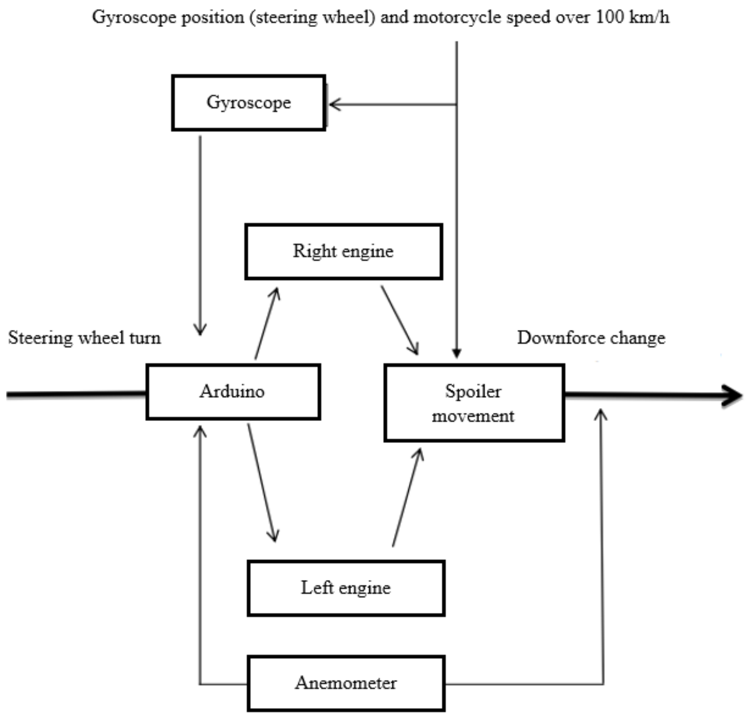
The spoiler design.

The design process of the spoiler begins with a thorough analysis of fundamental aerodynamic principles. The primary goal of the active spoiler is to counteract the suction effects generated in the slipstream, which hinder trailing riders when attempting to overcome inertia and brake into corners. This type of wing adjusts automatically to increase aerodynamic load on the sides of the motorcycle, adapting to the lean angle and direction of the curve.

The spoiler design.

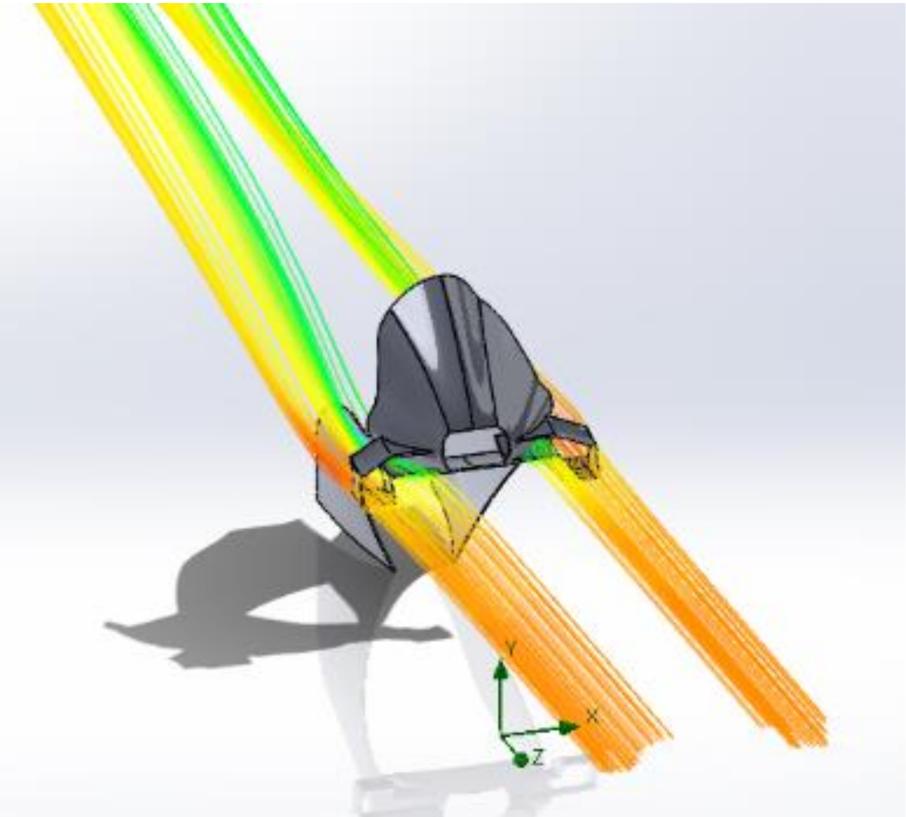
- **Electronic Control:** An Arduino Uno board based on the ATmega328 microcontroller.
- **Communication control:** The MPU6050.

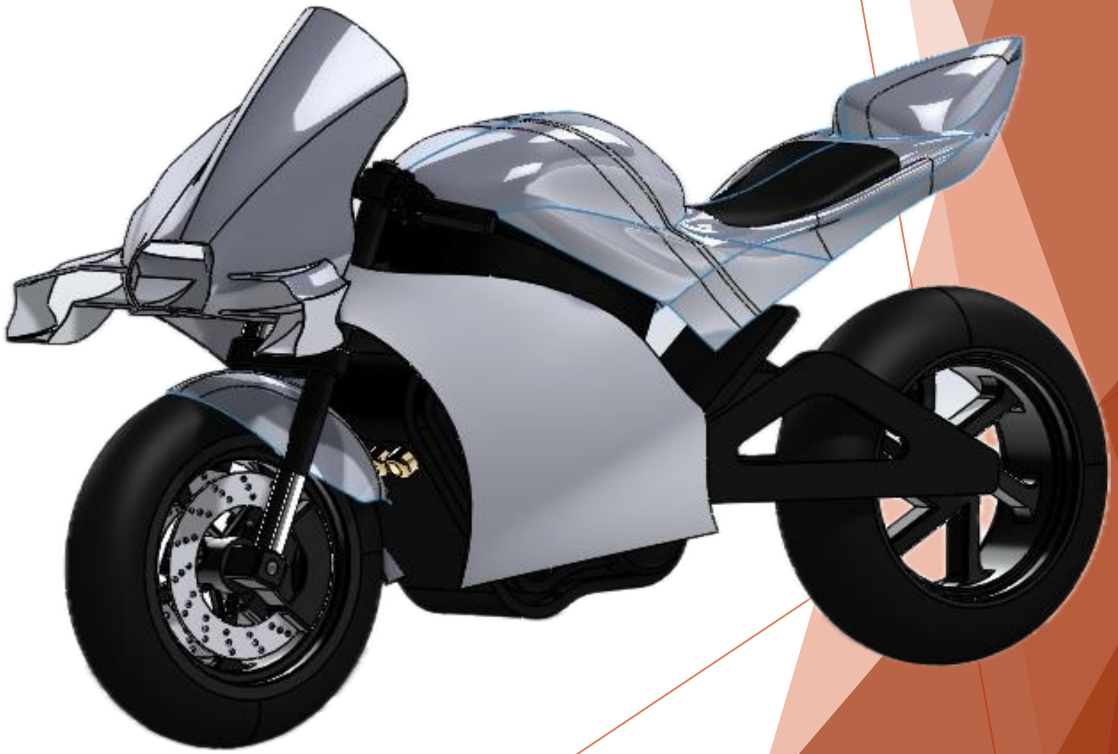




The spoiler design results.

Based on the established design, fluid dynamics simulations (CFD) using SolidWorks were conducted to evaluate winglet efficiency. These tests illustrated the airflow distribution over the winglet at different speeds, demonstrating its aerodynamic performance in generating the desired downforce.

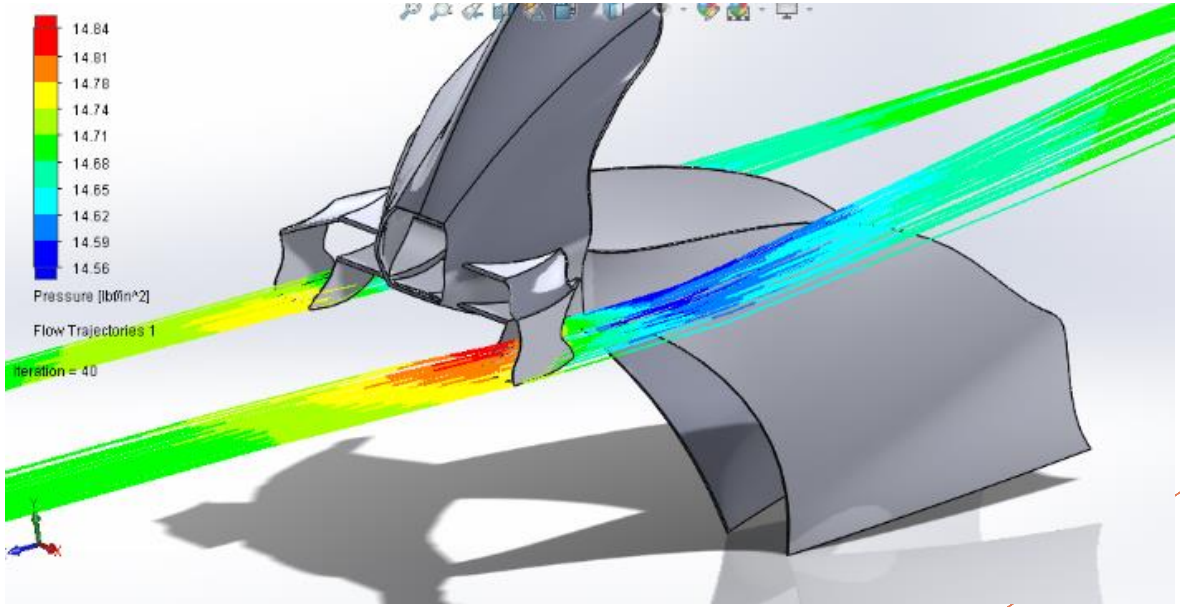




The spoiler design results.
(principal function).

The prototype successfully achieves the overall objective of designing an electronic control system using an Arduino board for an active winglet on a MotoGP motorcycle. Its primary functions include generating increased aerodynamic load where needed, improving performance and stability during high-speed cornering:

- **Principal function of the winlet**: winglet set at a 20° angle of attack, airflow lines show a reduction in speed from 220 km/h to 130 km/h, indicating efficient downforce generation by pressure variations where the winglet angle influences pressure increase from 14.6 psi to 15 psi.

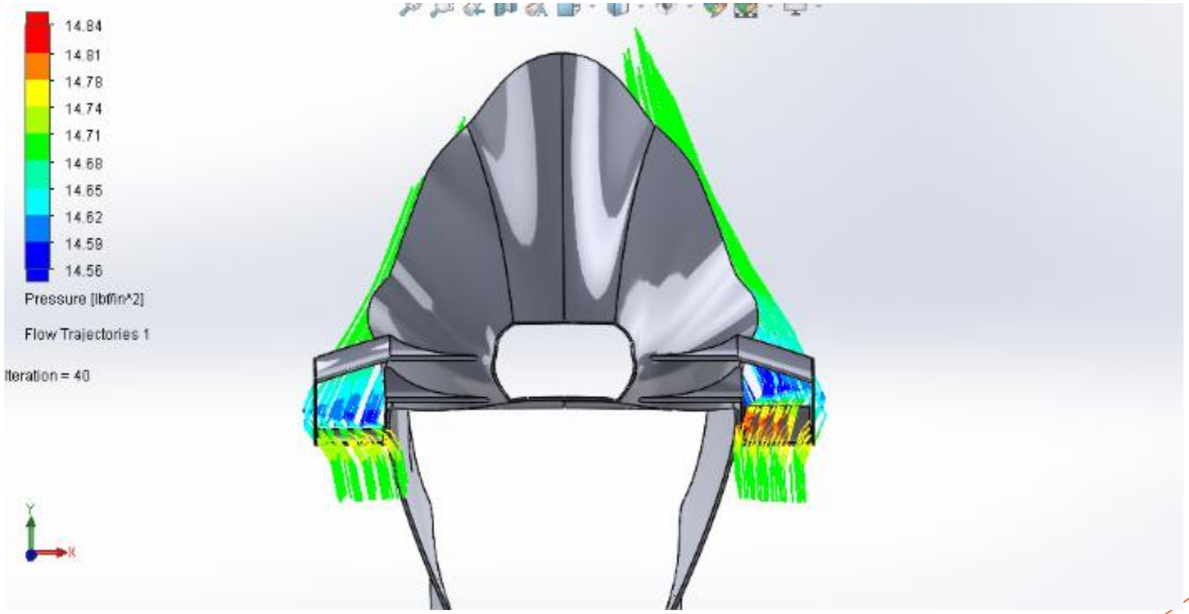


The spoiler design results.
(differences)

The flow and pressure differences between the right-wing (in motion) and the left wing (in neutral position). These differences demonstrate the effects of aerodynamic principles such as Bernoulli's law.

Right wing shows: higher pressure and lower velocity on the upper surface, while the lower surface exhibits lower pressure and higher velocity.

Left wings: minimal pressure variations and a slight vacuum at the rear due to the uniform airflow speed through the upper and lower parts.



Mathematical results.

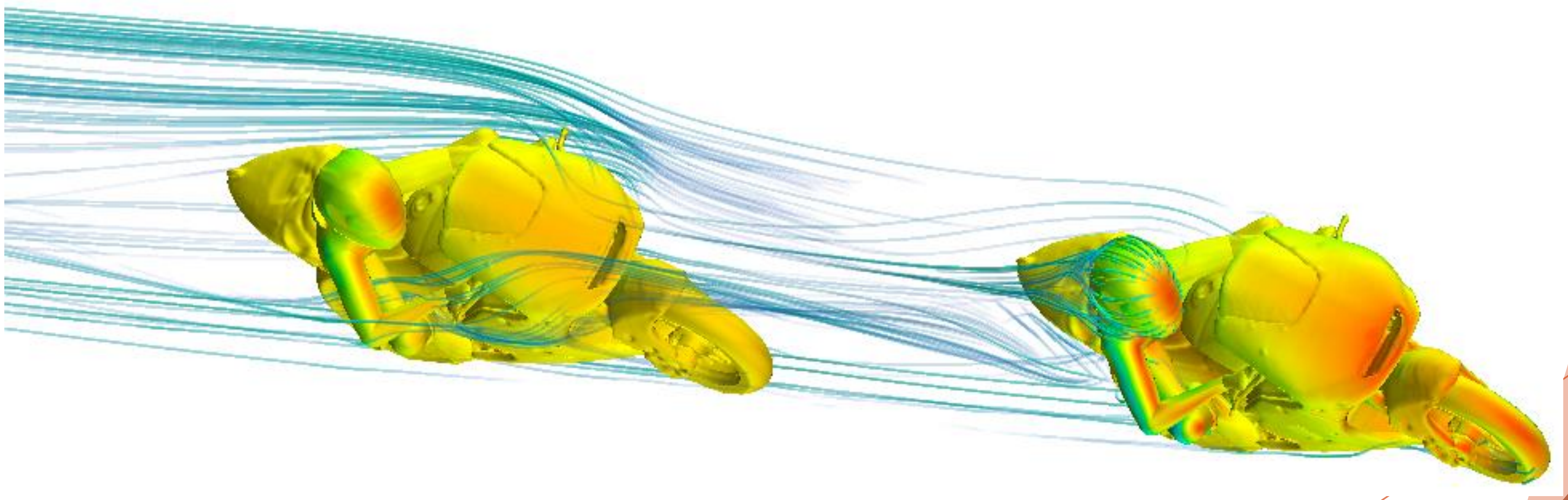
- **Principal equation:** **F=ΔP×A**

$$\Delta P = (15psi - 14.6psi) \times 6894.76\,Pa$$
$$\Delta P = 0.4psi \times 6894.76\,Pa$$
$$\Delta P \approx 2757.904\,Pa$$
$$A = 94cm^2 \times \frac{1m^2}{10{,}000cm^2}$$
$$A = 0.0094m^2$$
$$F = 2757.904\,Pa \times 0.0094\,m^2$$
$$F \approx 25.904\,N$$

$$F_{kg} = 25.904\,N \times 0.10197\,kg/N$$
$$F_{kg} \approx 2.644\,kg$$

Conclusions

The prototype developed in this research successfully achieved all its design objectives. As observed in the results section, the obtained values are beneficial across all aspects, generating significant aerodynamic loads that assist riders in braking and maneuvering more efficiently while in the slipstream of other riders.



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