



Airfoils in Motorsport

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Introduction

The first airfoil was developed by Zhukovsky where he used a mathematical concept that exploits the theory of complex variables- the conformal transformation. Theodorsen then took this concept and developed arbitrary shape airfoils, that subsequently became a practical aerodynamics design tool in 1931 (Houghton, Valentine, 2017).

The airfoil is the most important shape in motorsport aerodynamics, due to its unique ability to increase downforce as well as decrease drag.

It is now used on nearly every vehicle in one way or another, from overall vehicle shape to small components, to improve efficiency and speed.

How an Airfoil Works

The basic principle behind an aerofoil is; that the longer side of the shape causes the air to flow faster over the face than the shorter side. Bernoulli's Principle states that an increase of speed in a fluid causes a decrease in air pressure. The increase of airspeed creates an area of low pressure, the slower side creates an area of high pressure. The combination of these two contrasting pressure areas creates an overall force in the desired direction.

The Coanda effect is where a fluid jet stays attached to a convex surface. This causes the air to stick to the slope of the airfoil and leave the wing in the direction of the end of the airfoil. With this, you can angle the trailing edge of the airfoil to cause the air to leave in an upward motion, and in conjunction with Newton's 3rd law of motion, we know that this action of pushing the air up and away there is an equal and opposite reaction pushing the airfoil or wing down.

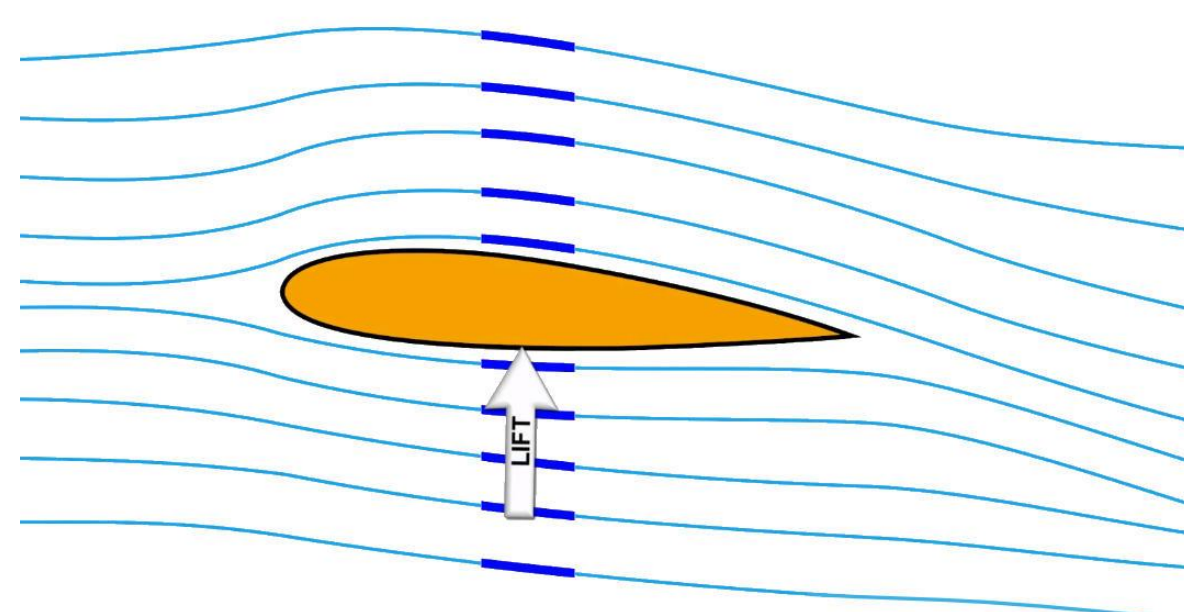
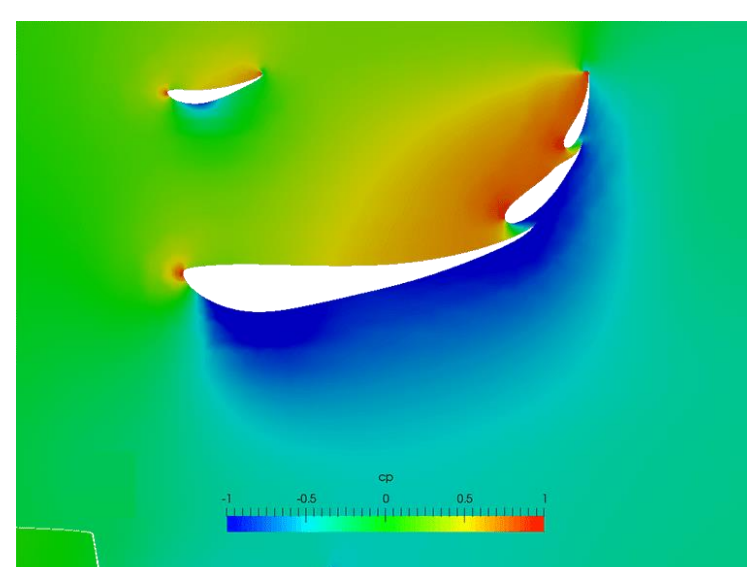


Figure 2: shows the effects of air from an airfoil producing lift. Due to the air flowing faster over the longer surface (Lesics,2019).



Pressure Coefficient plot on a high downforce setup on the rear wing of a Formula Student car (Pfeiffer, 2023)



The Chaparral 2E, which raced in the 1966 Can-Am series, was unlike any other competitor, due to the large rear wing mounted 4ft above the rear decklid. This rear wing generated 110kg of downforce at 100mph. (Barlow,2016)



Lotus 49, the first car to implement the airfoil shape front wing in F1 (RacingFeed, 2020)

Introduction of Airfoils in Motorsport

The very first car in F1 to use an airfoil device was the Lotus 49 in the 1968 Monaco Grand Prix. And ever since wings have played a crucial part in Formula 1 (RacingFeed,2020). In modern day Formula 1 every component that is liable to have the air go over it is streamlined into an airfoil shape, each specifically designed to

either produce downforce or change the direction of airflow into or away from the car's body. In modern F1, airfoils deflect air off the back of the car, upwards. This decreases the amount of dirty air behind the car and helps the racing become closer, due to cars having similar aerodynamic properties to the cars in front. Wings in F1 have developed substantially since 1968, however, the principle stays the same, force the car down.

Coefficient of lift

Lift Force can be calculated in the formula;

$$LF = C_L \times \frac{1}{2} \times \rho V^2 \times A$$

The coefficient of lift is used to determine the amount of lift force created; it is constant. The actual force that lifts the object is Lift. Using the CL, you can equally compare the amount of lift produced between different sized and shaped objects. Using this information, it is easier to compare different prototype models to find the one with the best results for the application (Tudor, 2024)

References

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