



Introduction to Automotive Aerodynamics

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Introduction

Aerodynamics is the study of the movement of air around an object and the forces applied by pressure during its movement. It plays a large part in car design in the motorsport and consumer sectors.

Vehicles are developed with aerodynamic considerations in order to minimise drag, and improve handling and stability.

Background

Drag is a force which acts against the movement of an object. The major drag force on a moving car is air resistance.

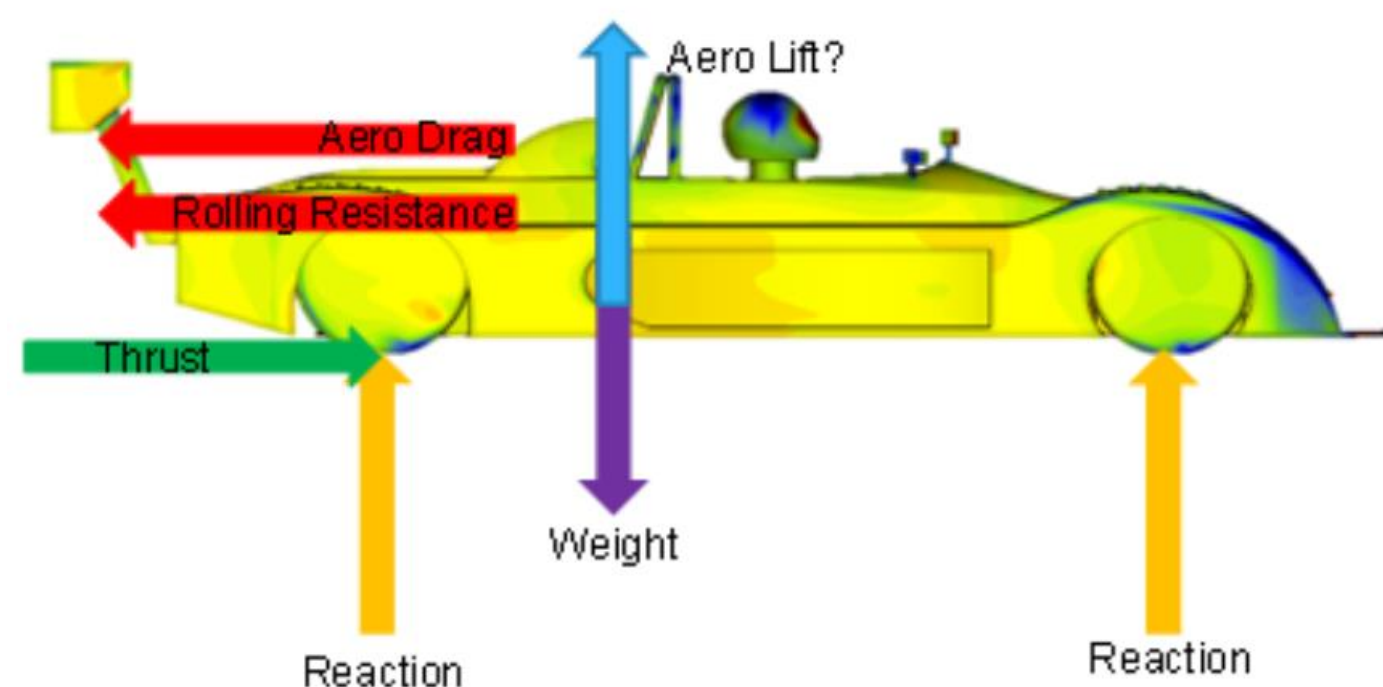


Fig.1 A diagram showing the different forces acting on a vehicle. (Tudor, 2020)

The coefficient of drag (C_D) is a dimensionless quantity used to express how much drag an object encounters. Drag can be reduced by minimising the frontal area (A) of the vehicle as shown in the equation below.

$$\text{Drag Force} = C_D \times \frac{1}{2} \rho V^2 \times A$$

Fig.2 An equation used to calculate the force acting against an object's motion.

The (C_D) of most road cars is typically between 0.25 and 0.4.

Bernoulli's principle states that as the velocity of air increases, the air's pressure decreases.

As air moves across a surface, its pressure applies force perpendicular to the surface. Lift occurs when there is a difference in the pressure above and below the vehicle.

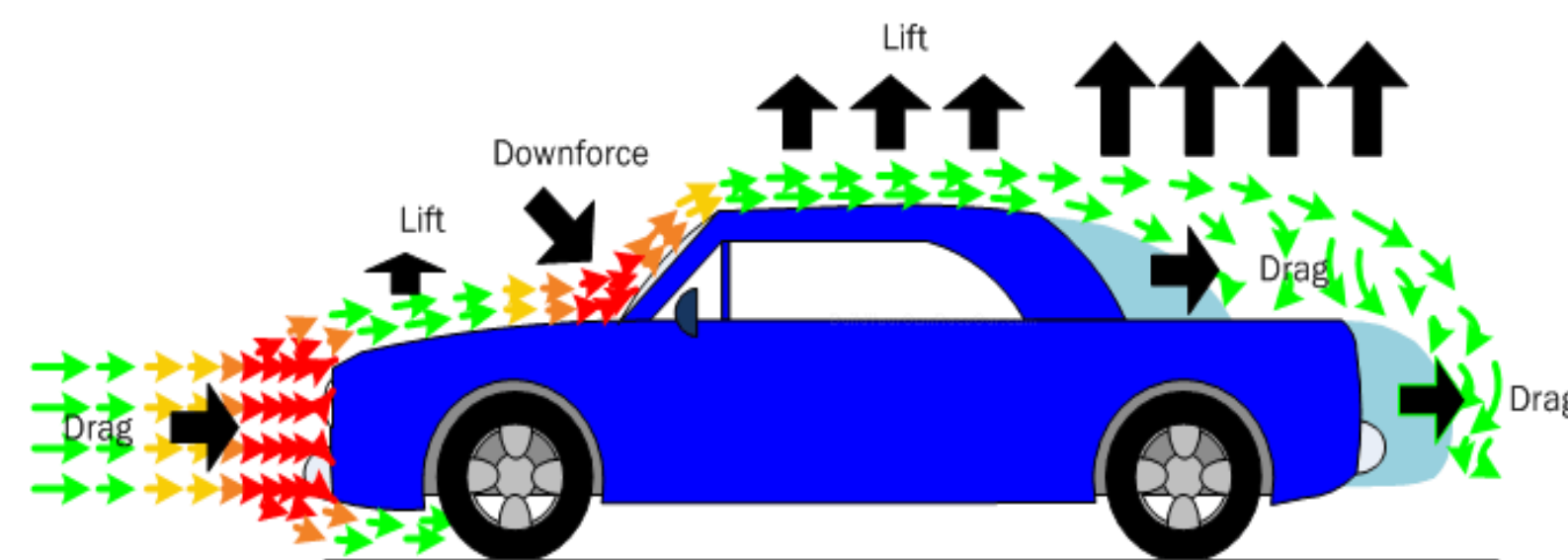


Fig.3 A diagram showing the aerodynamic forces acting on a vehicle. Green is low pressure, yellow is medium, and red is high pressure. Rear vacuums, shown in light blue, form due to separation. (Image from www.buildyourownracecar.com)

When air flows smoothly around the body of the vehicle it is referred to as laminar flow. If the body shape changes too fast, the air detaches and becomes turbulent, this is called separation and is what causes the rear vacuum. Turbulence induces drag and inhibits lift.

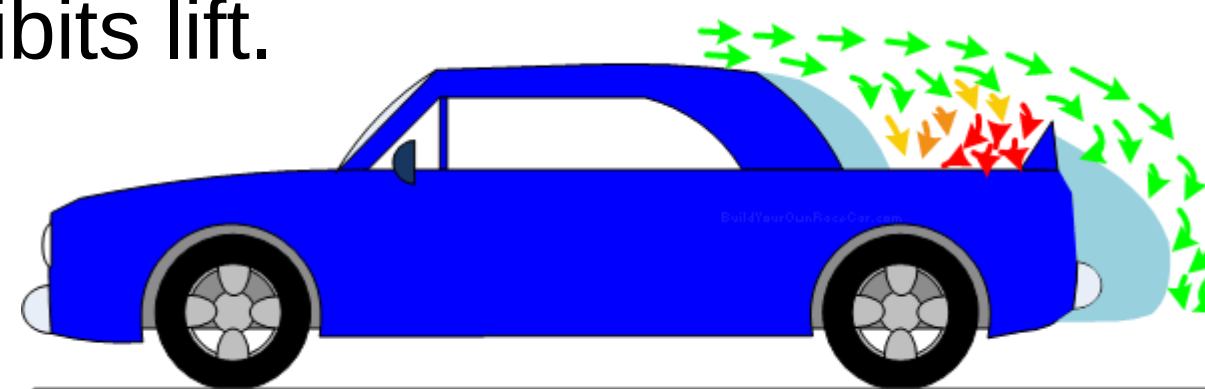


Fig.4 A diagram of the airflow around a car with a spoiler. The high pressure air in red is where the increased downforce is applied. The light blue rear-vacuum area has reduced due to the use of a spoiler. (Image from www.buildyourownracecar.com)

Aero devices are used to increase downforce and lessen separation. A wing produces downforce by creating lift in the direction of the ground. Diffusers smooth the transition between the bottom of the car and the rear. This also creates downforce by accelerating the air, reducing pressure underneath the car.

The effects of the aerodynamics of cars are tested through:

- Computational fluid dynamics (CFD)
- Wind tunnels
- Real-world testing.

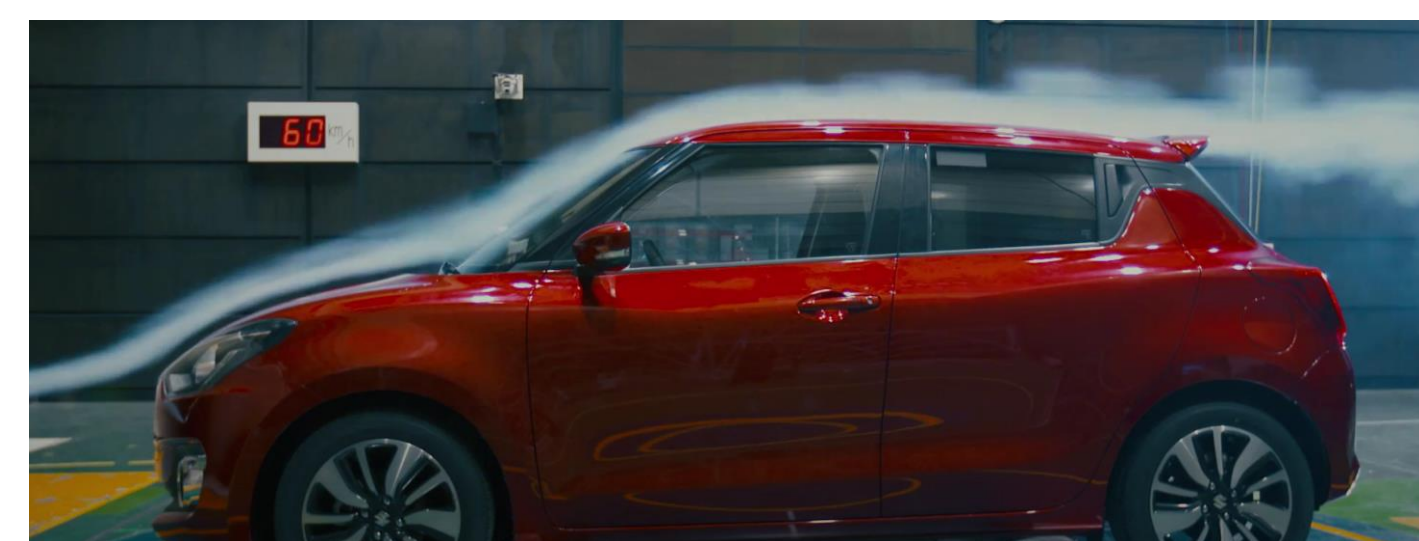


Fig.5 A Suzuki Swift in a wind tunnel. Smoke is used to make the airflow visible. (Image from Suzuki Global)

Discussion

Reducing drag improves the fuel consumption of vehicles, which is vital in the automotive industry as emissions standards become stricter. Less drag also allows a car to achieve a higher top speed.

A gain in downforce increases the load on tyres, improving their grip. This enables cars to corner at higher speeds.

Conclusion

The use of aerodynamics allows a vehicle's body to be developed to enhance its performance and efficiency.

References

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