Wind Tunnel Testing Laboratory

ARO 4351L – 01

Low Speed Wind Tunnel Report: R. J. Mitchell Wind Tunnel

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Introduction:

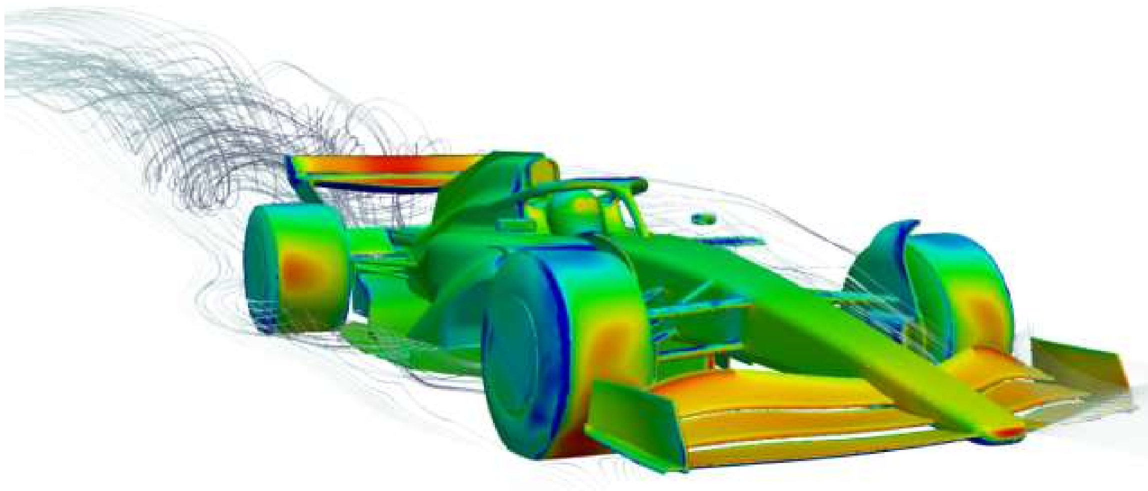
At the University of Southampton located in Southampton, England there exists a subsonic wind tunnel known as the R. J. Mitchell Wind Tunnel that can be used to test cars, unmanned air vehicles (UAV’s), aircraft / aircraft components, cycles, and boats. The wind tunnel was named after R. J. Mitchell who designed the Supermarine Spitfire and was created by his son Gordon Mitchell. The tunnel was first built in the 1930s and was purchased by the University of Southampton in 1979. The uniqueness of this tunnel is the test section size which allows for large scale models to be placed and as well as full scaled objects to be tested. This tunnel has been used by Olympic Athletes to refine everything from their equipment to their posture and as well as Formula 1 teams testing the aerodynamics of their Indy cars. The wind tunnel allows automotive brands, aerospace companies, university students, and university researchers to achieve a better understanding of the aerodynamic behaviors of their design.

Summary:

The RJ Mitchell Wind Tunnel at the University of Southampton features test section dimensions of 3.5 m in height, 2.4 m in width, and 10.5 m in length, making it the university's largest wind tunnel. It is operated by a 746 kW (1,000 hp) electric motor, which powers a large fan to produce the airflow necessary for aerodynamic testing. This setup enables the wind tunnel to achieve wind speeds ranging from a minimum of 4 meters per second up to a maximum of 40 meters per second (Mach 0.11). Furthermore, the tunnel is equipped with a moving belt system, with dimensions of 1.95 m in width and 4 m in length. This system features a dual-stage boundary layer suction and can reach speeds up to 40 meters per second. The maximum Reynolds Number achievable in the tunnel is 3.64×10^6meters, with the capability to handle pressures up to $1.58\ \mathrm{kN/m^2}$, allowing for a wide range of aerodynamic testing.

The wind tunnel's testing capabilities are enhanced by a 6-component head overhead balance, equipped with versatile mounting options, along with an underfloor 2-component balance. The overhead balance is adept at measuring a variety of forces and moments, such as lift, drag, side-force, pitch moments, yaw moments, and roll moments, making it suitable for a wide range of applications including unmanned air vehicles, underwater autonomous vehicles, and drag reduction investigations for semi-trucks, among others. The 2-component balance, on the other hand, is primarily utilized within automotive applications for the analysis and optimization of drag reduction. Furthermore, the tunnel is designed to accommodate maximum loads and moments, including a Pitch Moment of 700 Nm, Yaw Moment of 260 Nm, Roll Moment of 120 Nm, Downforce of 3600 N, Side force of 1000 N, and Drag of 900 N, showcasing its capacity to handle various aerodynamic testing scenarios.

Data collection in the wind tunnel is achieved using a Zero Offset Calibration (ZOC) pressure scanning system alongside 2D Particle Image Velocimetry (PIV). The ZOC system is utilized to gauge pressure differences across vehicle surfaces, providing a visual on how air pressure varies in response to different geometries and configurations. The 2D Particle Image Velocimetry (PIV) captures the behavior of fluids in their flow. By tracing the movement of particles dispersed in the airflow, the 2D PIV method allows for a visual representation of fluid dynamics, providing a clear picture of how air moves around and interacts with objects in its path.



Conclusion:

The R.J. Mitchell Wind Tunnel at the University of Southampton is a groundbreaking wind tunnel to test low speed aerodynamics for cars, aircraft, and even sports equipment. This special wind tunnel has been helping aerodynamicists understand aerodynamics since the 1930s and became a part of the university in 1979. In conclusion, the R.J. Mitchell Wind Tunnel serves as an optimal testing site where engineers and designers achieve aerodynamic goals in their projects.

References:

"R.J. Mitchell Wind Tunnel." National Wind Tunnel Facility
https://www.nwtf.ac.uk/facility/r-j-mitchell/

University of Southampton. "Large Wind Tunnel: 3.5m by 2.4m by 10.5m | University of Southampton." University of Southampton,
https://www.southampton.ac.uk/research/facilities/large-wind-tunnel-3.5m-by-2.4m-by-10.5m#:~:text=Wind%20tunnel%3A%203.5m%20by,10.5m%20%7C%20University%20of%20Southampton