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Two-Dimensional Dynamics Motion Simulations of F1 Rare Wing-Flap

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Abstract : In the realm of aerodynamics, numerous vehicles incorporate moving components to enhance their performance. For instance, airliners deploy hydraulically operated flaps and ailerons during take-off and landing, while Formula 1 racing cars utilize hydraulic tubes and actuators for various components, including the Drag Reduction System (DRS). The DRS, consisting of a rear wing and adjustable flaps, plays a crucial role in overtaking manoeuvres. The DRS has two positions: the default position with the flaps down, providing high downforce, and the lifted position, which reduces drag, allowing for increased speed and aiding in overtaking. Swift deployment of the DRS during races is essential for overtaking competitors. The fluid flow over the rear wing flap becomes intricate during deployment, involving flow reversal and operational changes, leading to unsteady flow physics that significantly influence aerodynamic characteristics. Understanding the drag and downforce during DRS deployment is crucial for determining race outcomes. While experiments can yield accurate aerodynamic data, they can be expensive and challenging to conduct across varying speeds. Computational Fluid Dynamics (CFD) emerges as a cost-effective solution to predict drag and downforce across a range of speeds, especially with the rapid deployment of the DRS. This study employs the finite volume-based solver Ansys Fluent, incorporating dynamic mesh motions and a turbulent model to capture the complex flow phenomena associated with the moving rear wing flap. A dedicated section for the rare wing-flap is considered in the present simulations, and the aerodynamics of these sections closely resemble S1223 aerofoils. Before delving into the simulations of the rare wing-flap aerofoil, numerical results undergo validation using experimental data from an NLR flap aerofoil case, encompassing different flap angles at two distinct angles of attack was carried out. The increase in flap angle as increase in lift and drag is observed for a given angle of attack. The simulation methodology for the rare-wing-flap aerofoil case involves specific time durations before lifting the flap. During this period, drag and downforce values are determined as 330 N and 1800N, respectively. Following the flap lift, a noteworthy reduction in drag to 55 % and a decrease in downforce to 17 % are observed. This understanding is critical for making instantaneous decisions regarding the deployment of the Drag Reduction System (DRS) at specific speeds, thereby influencing the overall performance of the Formula 1 racing car. Hence, this work emphasizes the utilization of dynamic mesh motion methodology to predict the aerodynamic characteristics during the deployment of the DRS in a Formula 1 racing car.

Keywords : DRS, CFD, drag, downforce, dynamics mesh motion
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