UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING AND APPLIED SCIENCE

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

THE AERODYNAMICS OF MULTI-ELEMENT WINGS IN GROUND EFFECT

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A comprehensive investigation into a multi-element wing in ground effect was conducted. A dual strategy was used within the research incorporating both experimental and computational techniques. The primary application of this research is within the field of motorsport. However the results also have applications within the field of aeronautics and offer insights into the flow physics of fundamental aerodynamic features.

The experimental test rig consisted of a generic multi-element wing supported by an automated motion system. Measurements were obtained in the form of forces, surface pressures, oil flow visualisations and off-surface flow field data. The experimental aspect of the research evolved from investigating basic configuration variables to quantifying the effects of passive flow control techniques. An evolutionary strategy was also adopted for the computational aspect of the research developing from an aerofoil in ground effect to a multi-element wing in ground effect. The computational results were obtained by solving the Reynolds Averaged Navier Stokes equations.

The experimental part of the research offered improvements over the current knowledge of ground effect and high-lift aerodynamics. At low ride heights the generated flow field and corresponding forces were found to be dependent on the direction or ride height variation, a novel finding. Variations in flap incidence directly influenced this dependency. An off-surface separation within the wake of the main element was found to be one of the primary lift-limiting mechanisms. The use of passive flow control was found to influence both the surface flow field and characteristics of the vortical flows. The computational aspect of the research also offered improvements over the current knowledge. Accurate predictions of a single element aerofoil, multi-element aerofoil and multi-element wing were obtained quantifying the effects of grid resolution, turbulence model and ride height.