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Effect of Inverted Aerofoil Geometry on Aerodynamic Performance in Ground Effect

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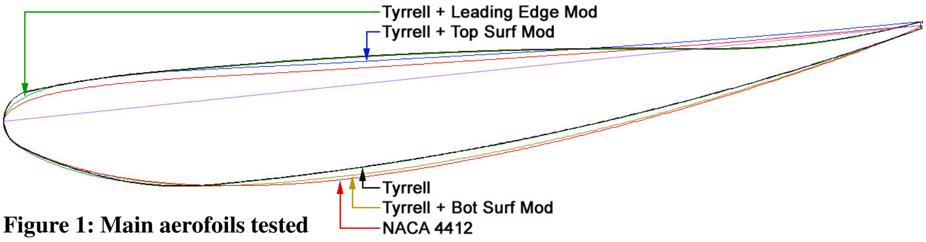

Figure 1: Main aerofoils tested

Background and Project:

- Ground effect is the aerodynamic phenomenon experienced by bodies moving in close proximity to the ground.
- Caused by augmentation of flow field induced by presence of the ground.
- Shown to be influenced by changes in body orientation and displacement from the ground.
- Influence of small geometry changes has not yet been examined – thorough understanding of mechanics of ground effect is lacking.
- CFD Study was undertaken comparing Tyrrell, NACA4412 and three hybrid aerofoils (**Figure 1**).
- Fine boundary layer mesh surrounded by unstructured and structured sections (**Figure 2**).
- Each hybrid replaces one feature of Tyrrell with equivalent feature of NACA4412, so effect can be observed.
- One additional hybrid aerofoil (**Figure 3**) was created to further clarify results.

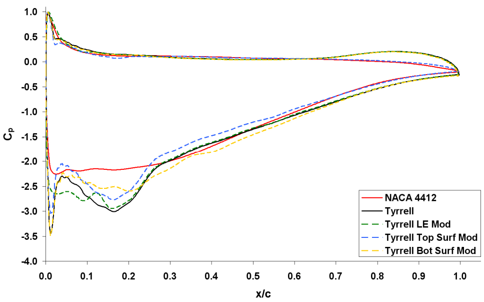

Figure 4: Pressure coefficient distributions

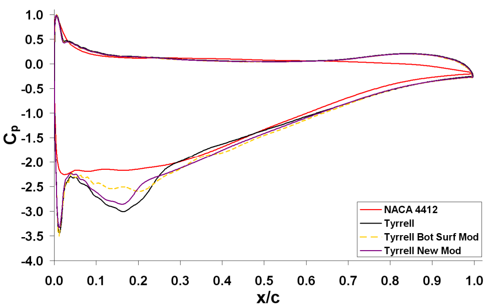

Figure 5: Tyrrell New Mod distribution

Results and Discussion:

From pressure coefficient distributions in **Figure 4**:

- *LE Mod:* Has no leading edge 'suction spike' but maintains suction thereafter – suggests leading edge curvature unimportant.
- *Top Surf Mod:* Eliminates pressure rise near trailing edge. Consistent loss of suction on bottom surface – suggests loss of circulation.
- *Bot Surf Mod:* It's smoother curvature maintains 'suction spike', reduces max suction region ($0.1 < x/c < 0.2$) and rapid pressure increase ($0.2 < x/c < 0.3$). Pressure gradient same as NACA4412 (but more suction). Has higher suction (than NACA4412) due to circulation from top surface camber.

From pressure coefficient distributions in **Figure 5**:

- *Tyrrell New Mod (Bot Surf Mod with lowest point moved forward to Tyrrell location):* Produced greater max suction – suggesting forward placement of lowest point is advantageous.

From velocity contour plots in **Figure 6**:

- *Bot Surf Mod* shows reduction in flow speed under aerofoil due to smoother curvature.
- Speed reduction under *Top Surf Mod* is worse due to lower circulation.

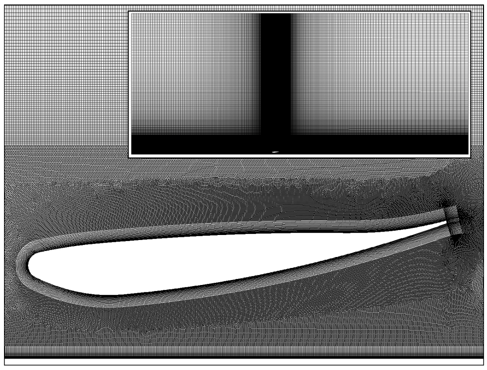

Figure 2: Computational mesh

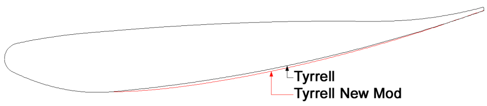

Figure 3: Tyrrell New Mod aerofoil

Conclusions:

- Ground effect performance of inverted aerofoils depends on: circulation generated about aerofoil; lowest point location and; smoothness of bottom surface curvature.
- Leading edge curvature has little influence on performance.

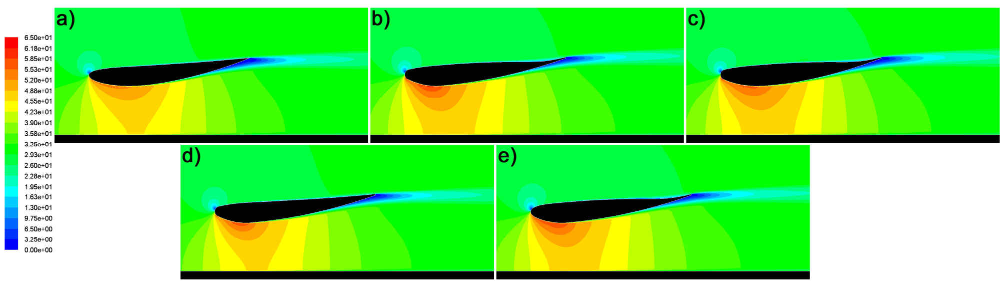

Figure 6: Velocity contour plots of main aerofoils: a) NACA4412 b) Tyrrell; c) Bot Surf Mod; d) Top Surf Mod; e) LE Mod

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