Case Study

B14 Centreboard

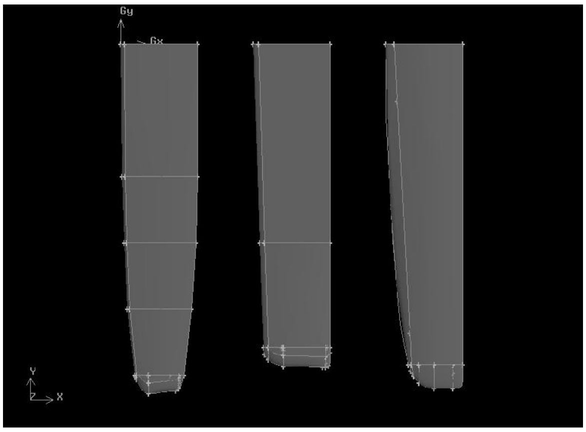

Figure 1: (left to right) UK, Australian and New Design centreboard

University: RMIT

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Discipline: Modelling

Research Objective:

To compare the performance characteristics of the current UK and Australia centreboard designs of the B14 14-foot racing skiff using digitised models. To design and trial a new B14 centreboard of superior performance to the current designs.

Significance:

The B14 is an international class of racing skiff with the main fleets in Australia, Europe, Japan and Hong Kong. At the recent World Championships boats from all fleets raced together for the first time and comparisons of each countries boat designs were made with the conclusion that the only major difference was the UK and Australian centreboards. Due to the B14 being a ?one design? class it is essential to know if one centreboard design has a distinct advantage over the other to allow for fair and even racing.

The production of a new centreboard with superior performance to both the current designs, if agreed upon, may be taken on by all B14 fleets as the standard design to increase the consistency of the “one design” concept.

Science Background:

The role of the centreboard is to develop a cross-boat force, which will oppose the force created by the sail. The desired centreboard design for a high performance boat such as the B14 has two main performance characteristics:

- Maximum lift force to allow the boat to point higher into the wind during tacking, and
- Minimum drag force to reduce resistance and increase the overall speed

Lift is caused by a difference in pressure on the upper and lower surfaces of an aerofoil and can be calculated using the equation:

Lift = Coefficient of Lift x Area x Dynamic Pressure

Drag can be split into two main areas; Parasite or Form drag caused by the the shape of the object and Induced drag which is caused by a component of the lift force. In regards to parasite drag the induced drag is quite small and therefore more emphasis is placed upon the parasite drag when dealing with design considerations. Parasite drag is caused when turbulent flow “scrubs” over the surface of and object, which is know as skin friction as well as the drag caused by pressure on the foil. Turbulent flow occurs at any speed greater than the critical speed at and below which viscosity can suppress turbulence. At these speeds the shearing force within the boundary layer causes a rolling motion and reverse flow occurs. This point is known as the separtion point. The parasite drag force can be calculated using the equation :

Drag = Coefficient of Drag x Area x Dynamic Pressure

In order to increase the lift force and reduce the drag force produced we wish to keep turbulent flow to a minimum and maintain a laminar flow over as much of the aerofoil surface as possible. Laminar flow is smooth and organised with no interchange of molecules between flow layers. Keeping the flow attached to the surface of the aerofoil increases the laminar flow and can be achieved by using foil shapes with smooth lines that do not change thickness drastically.

Methodology:

- Create computational models of the UK & Australian centreboards and mesh in Gambit
- Run models in Fluent at differing velocities and angles of attack.
- Analyse and Record essential data such as Coefficients of Lift and Drag, Dynamic Pressure, Lifting Area and Turbulence intensity.
- Compare results for UK and Australian board in terms of Lift and Drag performance characteristics.
- Design and test a new B14 centreboard and compare results with current designs.

Modelling

The tool used for creating the centreboard models and the digitised mesh was the CAD program Gambit. Gambit was used as it can easily transfer the centreboard meshes into the CFD program Fluent that is what was used to analyse the lift and drag characteristics of the centreboards. Fluent was the CFD program of choice as it had all the desired features for comprehensive analysis as well as previous experience with the program.

Speedup

Number of Processors: 4

The speedup time for the run Fluent jobs is almost linear, for example, 2 processors causes a speedup of twice the speed observed for 1 processor.

Results:

Comparing UK and Australian centreboards

From the results obtained it can be seen that the UK design performs better with regard to lift and the Australian design performs better with regard to drag at all velocities and angles of attack. Both boards produced similar lift to drag ratios but the change in leeway angle due to the UK boards superior lift did not effect the overall performance of the boat as significantly as the Australian boards smaller resistance force. Therefore it was concluded that the Australian board performed better than the UK board in all conditions, except for very light winds due to the UK boards greater length and resistance to stall.

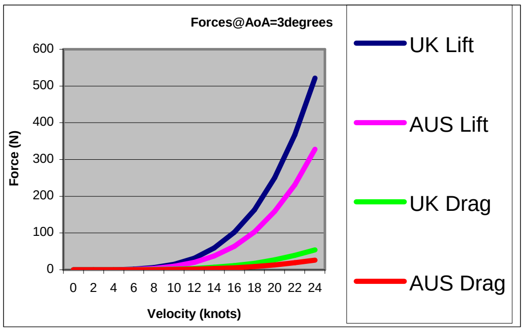

Figure 1: Lift/Drag of UK and Australian centreboards at AoA = 3 degrees

Design of new centreboard

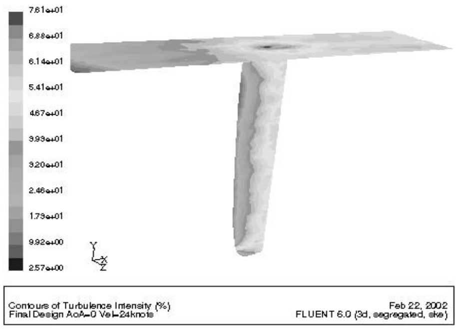

Figure 2: Contours of Turbulence Intensity of the new design

Using the results of the UK and Australian centreboard comparison and relevant field literature a new centreboard was designed with superior lift and drag performance characteristics then both current designs. The board aimed to get the best of both worlds with the greater lift of the UK board and the lower drag of the Australian board. In order to do this the board uses a foil shape that is similar to the foil used on the Australian board at the root of the new design, with maximum thickness occurring at approximately 50% chord and a foil similar to that used by the the UK board at the tip with maximum thickness occurring closer to the leading edge. This change in foil shape along the length of the board reduces the tendency of tip stall. The new board also has a larger sweep back angle and taper ratio with a curved leading edge to reduce drag.

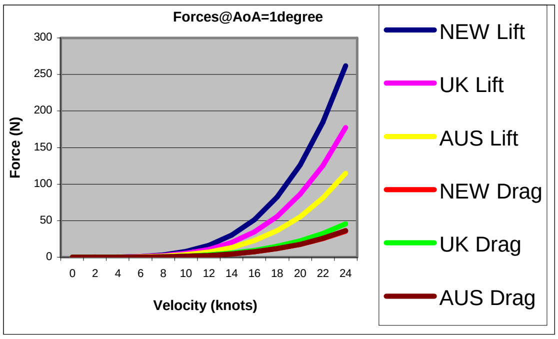

Figure 3: Lift/Drag of UK, Australian and the new design centreboards at AoA = 1 degrees