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AC45 Technical Note No2

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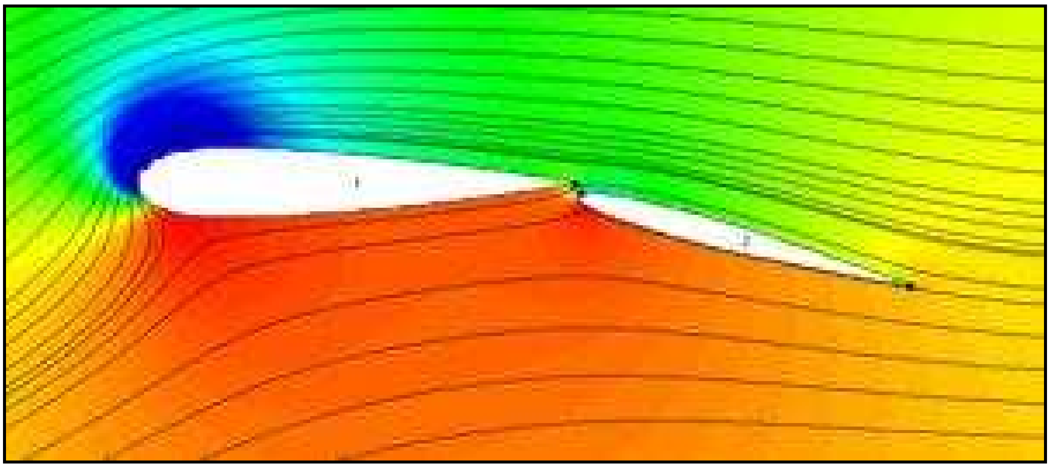

Figure 1 – Streamlines around wing

Introduction – Discussion on camber

Discussion on wing camber, sailing and trimming a Wing.

Wing vs Soft Sail

A soft sail on a fixed mast provides a maximum upwind lift co-efficient of about Cl=1.5. A rotating mast can provide a Cl=1.8. Downwind they both provide about Cl=1.0. A two panel wing can provide an upwind Cl=2.5-3.0 and downwind a Cl=2.0. So all round it provides more lift then the soft wing does. Plus at all points of sail the Wing has much less drag, probably 1/10th the drag of a soft sail.

Something that has been a quandary for me for a while has been how to trim a Wing? On a soft sail we trim it by using the sail telltales and the steering telltales to adjust the sail. But on a Wing we may not be able to see the lee side telltales very well. On a soft sail the Lee side telltales are the most important ones to get right.

Answer – we can use the windward side telltales to indicate we have the Wing set right.

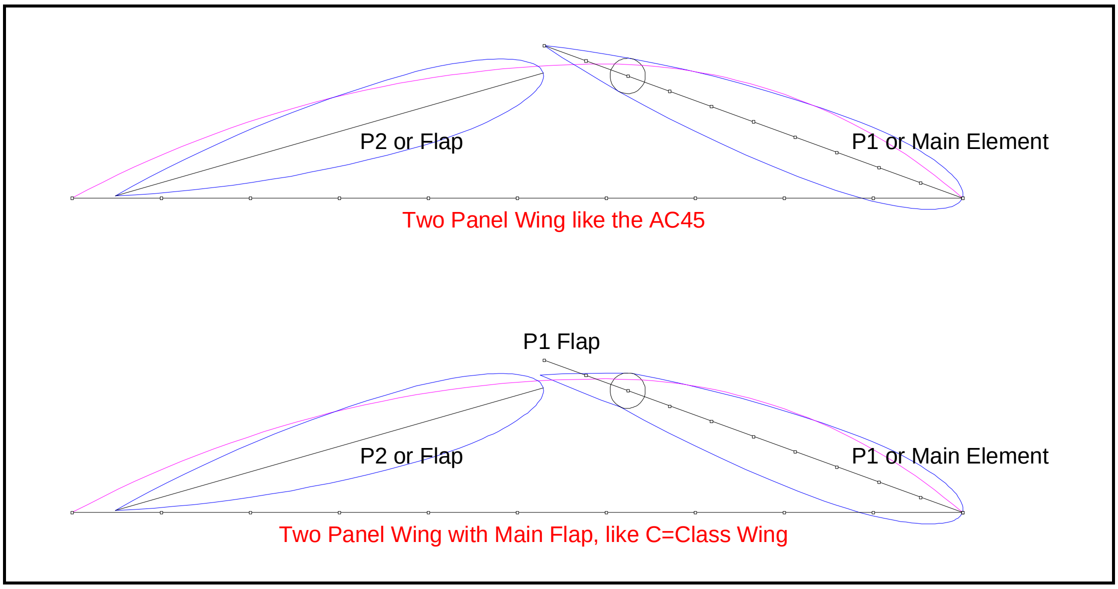

Figure 2 – Wing (36deg camber) Vs Soft Sail (15% camber). Note in some designs the trailing edge of Panel 1 (P1) has an extra small flap which allows the TE of P1 to better blend with P2. We would have this P1 flap on the AC72

Aerodynamics

A soft mainsail and mast combination has windward and leeward vortices that create drag resulting in a low lift co-efficient. A Wing removes these vortices and also allows sail control that a soft sail can't provide. Figure 2 shows a soft sail and a Wing overlaid. The soft sail has a camber of 15% and the Wing has a camber of 36degs. We describe camber in sails and wings differently. In practice a 15% sail is an upwind high lift, high drag combination. The wing on the AC45 can be cambered to 40degs so Figure 2 is drawn at about its maximum camber. Looking at Figure 1 we can see that there are no vortices around the Wing. The slot extracts the air from behind the area that usually creates the windward vortice preventing the vortice formation. It can also be seen that the stagnation point is well aft of the nose of panel one so the nose telltales need to go around quite a way.

Results

A row of nose telltales needs to be installed on the leading edge of the Wing. These need to be placed initially at four heights and in a line say at 45degs across the LE. The aim of these are to indicate the position of the stagnation point of the leading edge of P1. As the LE of an AC45 Wing does not twist the aim is to get the top or the bottom of the Wing working or as much of it as possible working. (An C=Class cat leading edge twists 15degs) Or the best parts of the wing working as yet not known until we develop a velocity profile for the boat. The bottom of the wing is used to minimise heel, the top of the wing is used to get more power. Generally the wind will be faster up higher. The Wing trimmer needs to learn about the LE variation in Stagnation Point (SP) and how it affects performance as we have no control over twisting the LE. But the SP will tell us a lot about what is going on with the Wing. Artemis had such a 45deg line of telltales on their wing.

Telltales also need to be placed along the wings Panel 1 and Panel 2. To begin with say five sets at varying heights. Once we find the critical ones, the non-critical ones can be removed. If the nose telltales are good (streaming backwards) then the lee side telltales will be good as well. This is a function of the foil shape of the wing. We do not need to change the shape of the sail to get the lee telltales right, this is built into the wing shape. This was the Eureka thinking moment!

What we do need to get right is the trailing edge (TE) twist, so we then look at the TE telltales and twist the flaps to suit.

Once the Wing trimmer develops an understanding of how the LE affects the Wing overall and can trim the wing to achieve what is needed (via reading off the configuration from the Velocity Profile), I think the nose telltales will probably not be needed as the trimmer will use camber and flaps intuitively. The main tool will be a speedometer like a velocitek. Just keep the boat speed set at huge!

Power Control

On a soft sailed boat we talk about changing gears. On a Wing sail its more like an accelerator pedal then a gear change. The pedal is the camber control. Usually the Wing would be used at an angle of about 20degs giving good lift and little drag, but max lift is at about 40degs. This means there is a zone of lift available simply by playing with the camber control. So something that will not be trained into the "soft" sailor is that by pulling on camber the boat will leap forward or heel over depending on the point of sail. This effect can be seen in C-Class racing starts. They hover at the start line and when the camber is pulled on they literally jump forward and accelerate over the line and into the race. Camber control will give overtaking opportunities and spurts of speed if used well.   Remember that the increased lift needs to be countered by increased righting moment, so the crew need to be in the right place if camber is pulled on quickly!

Tacking and Gybing (T&G)

There are a couple of things that can go wrong in tacking and gybing a Wing. If done slowly the drive can reverse and this pitchpoles the boat backwards. This does happen on C-Class boats occasionally. The main point I want to make here is that T&G can happen really fast as there is no need to settle the sail into its correct shape. It is already in its correct shape it just needs to change sides quickly & smoothly. In videos and from observation I've seen crew pushing the Wing across in the middle. It seems like the hinge line is a bit sticky. So it will be important to build these very accurately and keep them lubricated to remove all the friction from the bearings and cable runs. The increased pretension on the control cables compresses the Wing and loads up the bearings. This increases the system friction. I'm looking at hydraulic controls for the AC72 to remove compression from the mast via the control cables.

Hope this all helps.

Any questions please ask.

Figure 3 – Cambered Wing but no twist