'Canard Foil' = Improved Keel Performance ? May 1983

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I have an idea that looks strange but which should be efficient. This is to fit a "canard" foil in front of the keel with two objectives :- to contribute to the lift (required by sails) and to delay seperation over the low pressure side of the keel.

The second point is less clear, I think the vortex rotation produced by the canard will direct higher velocity water close to the keel into the boundary layer (low pressure side) and help keep the flow attached thus delaying stall.

Seperation will be insignificant when Reynolds number is small (absolute values) and so the canard will not be a benefit on calm days. When more lift is required and there is higher pressure on the leeward side of the keel seperation limits the amount of lift available and the canard should delay this point of stall.

From the figures you may note that I chose a "keel canard" configuration of 20 degrees sweep forward in one case. I like this for the beneficial characteristics of forward sweep, it is not important to this idea but note that the weak point of "sweep forward" is "root stall" so here again the canard is beneficial because the vortices of the canard are working in the root zone of the keel.

As it will not be efficient on calm days the canard must be retractable. The section being constant will not leave a gap or slot in the hull. When raised a high aspect ratio keel will remain which will be optimum when limited lift is required. As there will not be an excess of lateral area the leeway will remain optimum giving a high Lift/Drag ratio and improved Vmg. As the wind increases and more lift is requred the canard can be lowered partially or totally.

I think with this canard configuration the boat will have a better distribution of lateral area and will therefore maintain a better course. When sailing free the canard is fully raised reducing wetted area.

For an equal keel area the canard configuration gives more lift and exerts less drag. This implies that the side force of the sails will be balanced with less wetted area leading to improved performance.

The calculations were made with theoretical equations that do not take account of the benefit of the vortex generated by the canard which if well positioned will lead to greater improvements.

Comparing the two configurations shows that the canard has more keel-hull interaction; the effect of this interference being beneficial. I think the success of the configuration will depend on its location (its fore and aft position). This is very difficult to predict by theory and must be tested in a tank.

Javier Soto Acebal is a 23 year old engineering student interested in yacht design. He would be pleased to hear other opinions.

To illustrate my idea I have compared a simple keel and the canard configuration, for the same boat and with the same lateral areas. I have chosen vertical foils for clarity and speed of calculation.

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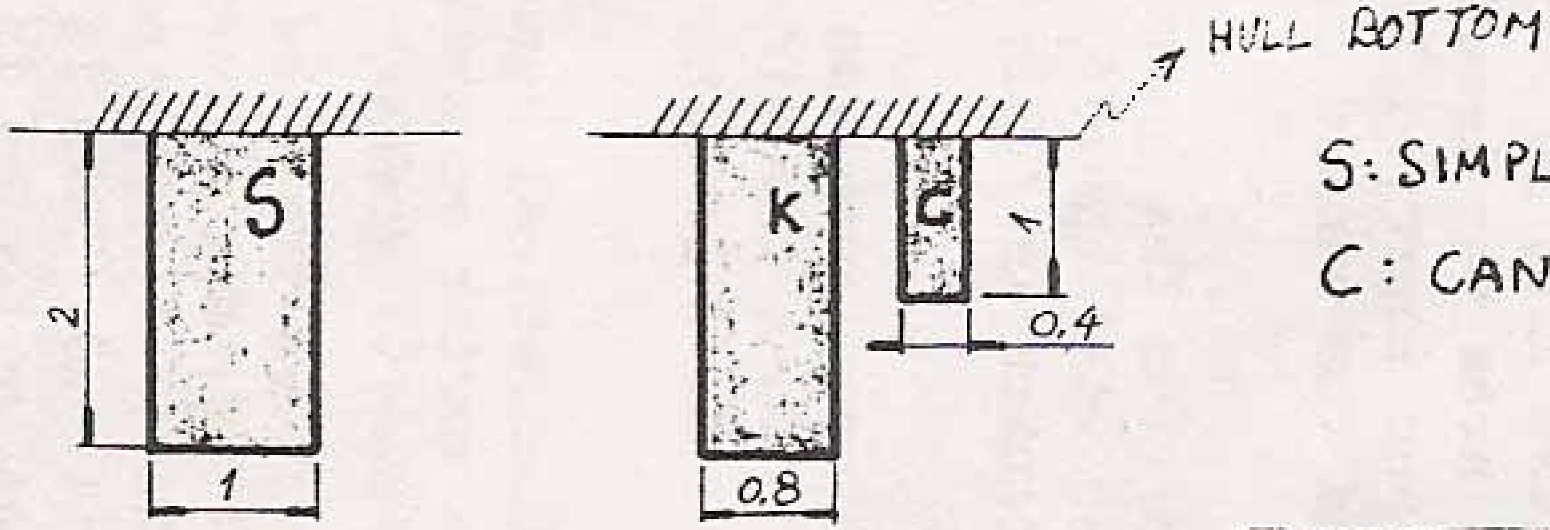


S: SIMPLE CONFIGURATION ; K: KEEL OF THE CANARD CONFIGURATION
C: CANARD ; CC: CANARD CONFIGURATION

EQUATIONS: LIFT COEFFICIENT: $C_L = \left(\frac{\partial C_L}{\partial \alpha}\right)\alpha + \frac{C_{DC}}{a}\left(\frac{\alpha}{57,3}\right)^2$

$$\left(\frac{\partial C_L}{\partial \alpha}\right) = \frac{0,9(2\pi)a}{57,3\left[\left(\cos\Lambda\sqrt{\frac{a^2}{\cos^4\Lambda}+4}\right)+1,8\right]}$$

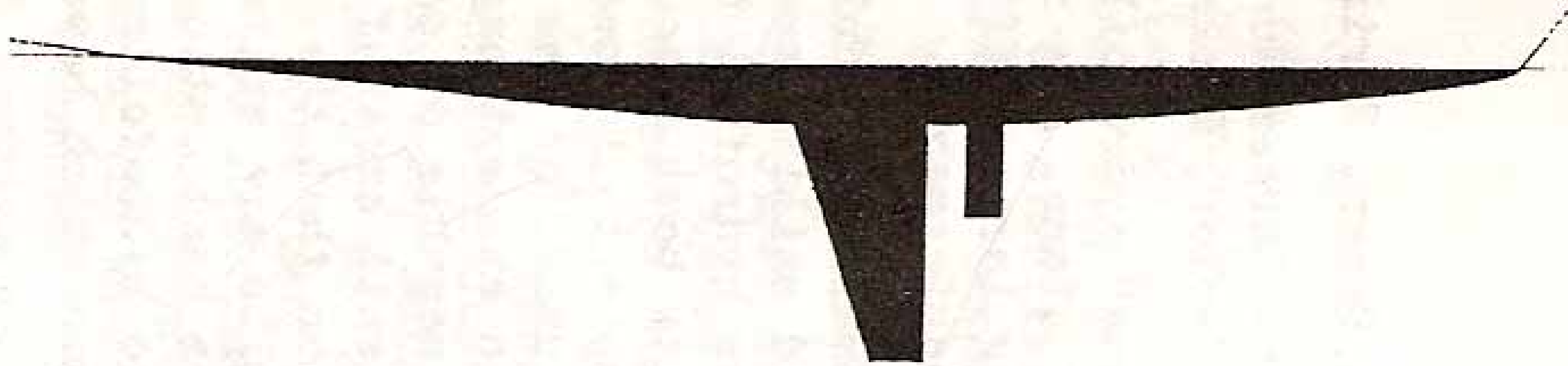
WHERE: a = EFFECTIVE ASPECT RATIO; Λ = SWEEP ANGLE; α = ANGLE OF ATTACK; C_{D_C} = CROSSFLOW DRAG COEFFICIENT

DRAG COEFFICIENT: $2 \rightarrow C_D = C_{do} + \frac{C_L^2}{\pi a e}$

WHERE: C_{do} = MINIMUM SECTION DRAG COEFFICIENT; e: "OSWALD EFFICIENCY FACTOR"

USING THESE EQUATIONS I OBTAINED:

$$\begin{cases} C_{L_S} = 0,2538 \; ; \; C_{D_S} = 0,01229 \\ C_{L_K} = 0,2763 \; ; \; C_{DK} = 0,0119 \\ C_{L_C} = 0,2763 \; ; \; C_{D_C} = 0,0119 \end{cases}$$



FORCES: $L_S = \frac{1}{2} \rho S_s V^2 C_{L_S} = K S_S C_{L_S}$ → WHERE: $K = \frac{1}{2}\rho V^2$ = CONSTANT FOR THE TWO CONFIGURATIONS

S_S = LATERAL AREA; IN THESE CASE = 2

THEN: $L_S = K \times 2 \times 0{,}2538 = K\, 0{,}5076$

↳ LIFT FORCE OF THE SIMPLE CONFIGURATION

$L_S = K\, 0{,}5076$

$L_{CC} = L_K + L_C = \frac{1}{2}\rho S_K V^2 C_{L_K} + \frac{1}{2}\rho S_C V^2 C_{L_C} = \frac{1}{2}\rho V^2 (S_K C_{L_K} + S_C C_{L_C}) = K C_{L_K}(S_K + S_C)$ →

→ $C_{L_K} = C_{L_C}$; THEN: $L_{CC} = K \times 2 \times 0{,}2763 = K\, 0{,}5526$ LIFT GENERATED BY THE C.C.

DRAG FORCES: $D_S = 2 \times K \times C_{D_S} = 0{,}0244\, K$ → DRAG OF THE SIMPLE CONF.

$D_{CC} = K [C_{D_K} S_K + C_{D_C} S_C] = 0{,}0238\, K$ → DRAG OF THE CANARD CONF.

Direction of travel ⟶

$\frac{L_S}{D_S} = 20{,}803$ $\frac{L_{CC}}{D_{CC}} = 23{,}218$