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Shakhov V. G., Liu Yang, Mo Bo, Ji Simei, Kurkin E. I.

INDUCED DRAG OF NON-PLANAR SYSTEMS

Induced drag is an important part of total drag. It corresponds to 30%-50% of the aircraft drag under cruise conditions. At the low speeds conditions (takeoff, landing) the induced drag is about 80% of the total drag [1]. So reduction of induced drag has drew many researchers. This paper focus on finding a minimum induced drag among a given geometry range, and analysis the effects of span, sweep angle, wing height, length of higher wing on C-wing, the direction of higher wing on C-wing on span efficiency factor and the position of aerodynamic center.

All calculation is conducted by Tornado which is a 3D-vortex lattice program. Tornado can output: 3D forces acting on each panel; aerodynamic coefficients in body and wind axis; stability derivatives with respect to angle of attack, angle of sideslip, angular rates and rudder deflections [2].

The comparison between Tornado results and Cone's results [3] is allowed to find a best mesh sizes. The results shows that accuracy is not sensitive to chordwise mesh if chord wise panels in more than 8 but semi-span wise mesh. Obeying founded mesh sizing we can control the accuracy within 4,7%.

In order to find the best geometry layout, different geometry parameter has been tried. Table 1 contains the investigated parameter range. Fig.1 shows the geometry layout of this case. For all cases tip ratio is equals 1.

Table 1 Geometry parameters

Parameter	Descriptions	Value
Λ_{LE}^{1}	Sweep angle of main wing	0; 15; 30; 45
h	Nondimensional height of vertical fins	0,5; 1; 1,5; 2; 2,5
b_1	Main wing aspect ratio	5; 7; 10
$2b_2 / b_1$	b_2 - is higher wing aspect raito	0; 0,25; 0,5; 0,75; 1
Λ_{LE}^{2}	Higher wing sweep angle	$\pm\Lambda_{LE}^{1}$

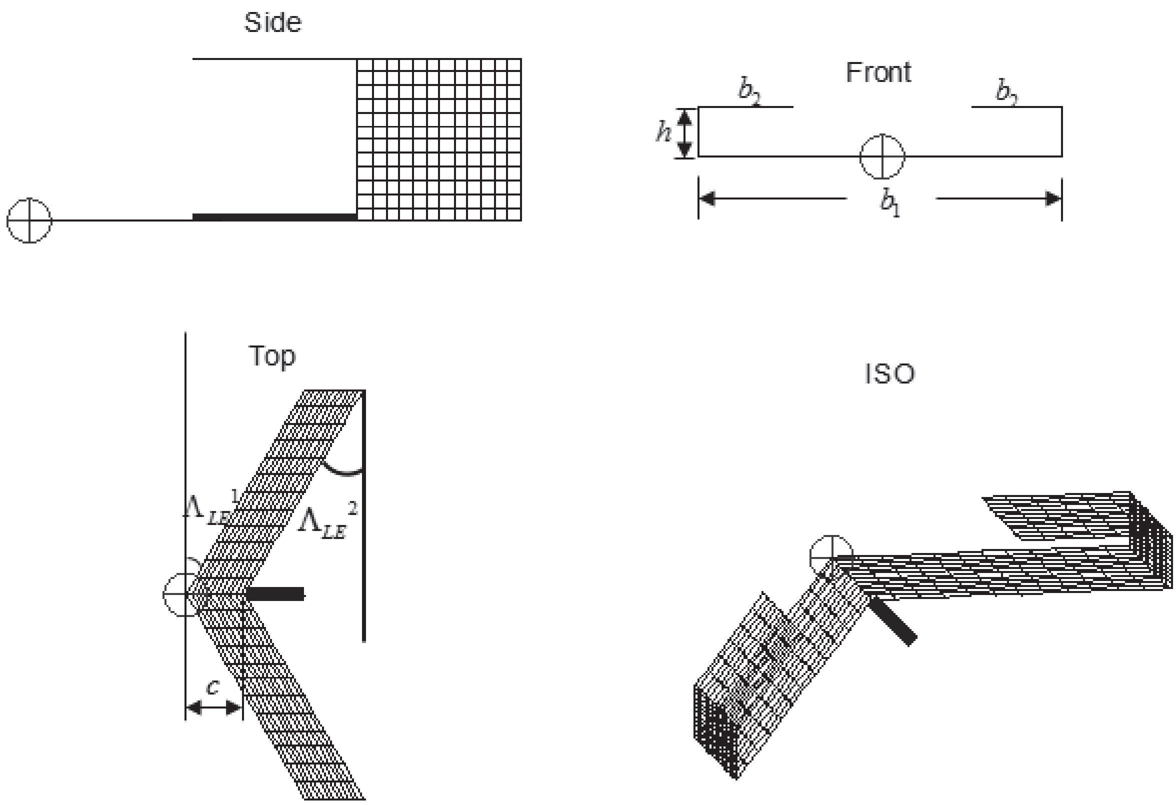

Fig. 1. Geometry layout of sample

It was verified that the results can be approximated by the following relations by angle of attack α: lift coefficient $C_L = C_L^{\alpha}\alpha$, induced drag coefficient $C_D = B\alpha^2$, pitching moment coefficient $C_m = C_m^{\alpha}\alpha$, position of aerodynamic center $x_{AC} = -\frac{C_m^{\alpha}}{C_L^{\alpha}}$, span efficiency factor can be defined as $e = \frac{(C_L{}^{\alpha})^2}{\pi b_1 B}$ [1].

Fig. 2 shows results of calculation for $\Lambda_{LE}^2 = -\Lambda_{LE}^1 = 30^\circ, b_1 = 7$, and variable $2b_2 / b_1$ and h. It shows that higher wing has bigger span efficiency factor and more back aerodynamic center. And when $2b_2 / b_1$ increases, e decreases firstly, and after $2b_2 / b_1$=0,5, e increases. When $2b_2 / b_1$ equals to 1, the e is biggest. Bigger $2b_2 / b_1$ leads to bigger x_{AC}.

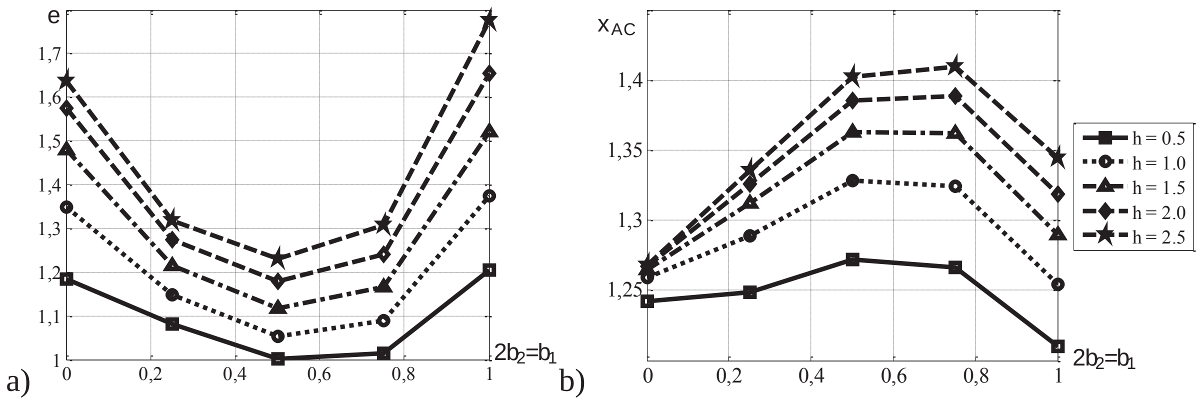

Fig. 2. Efficiency factor (a) and position of aerodynamic center (b) for $\Lambda_{LE}^{2} = -\Lambda_{LE}^{1} = 30^{\circ}, b_1 = 7$

References

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