DOWNWASH FLOW INVESTIGATIONS FOR PASSANGER AIRPLANE

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Abstract

It is well known, that in the area of horizontal tail exists downwash of a flow, where the direction of local velocity differs from the direction of the a flow. The knowledge of downwash is necessary for the definition of conditions of the flow near the horizontal tail and balancing.

In this paper there are some results concerning the experimental investigation of downwash values a flow near the horizontal tail of the typical passenger airplane with sweep high aspect ratio wing. This investigation was done with different high lift devices in TsAGI's low speed wind tunnel T-102. The influence of ground effect is considered. The experimental data have been compared with the calculation data.

Is shown, that the values of downwash for all considered configurations of model form uniform dependence on the value of lift coefficients - CL and the distance up to the screen.

1. Introduction

Experimental way to determine the average angle of the downwash flow consists in measuring the pitching moment of the aircraft model without the horizontal tail - $Cm_{w/o\ h.t.}$ (alpha) and with horizontal tail - Cm(alpha, φ.) depending on the angle of attack α at several values of the angle of stabilizer setup φ. It follows from the geometrical relation between angles alpha, φ, downwash angle ε and aerodynamic angle of attack of h.t. $\alpha_{h.t.}$ = alpha + φ - ε that if $alpha_{h.t.} = 0$ holds then ε = α + φ. The condition $alpha_{h.t.} = 0$ holds at the points where $Cm_{w/o\ h.t.}$ (alpha) = Cm (alpha, φ.) for stabilizer projected with the use of a symmetric airfoil. Downwash angles are being calculated at these same points, dependencies ε(alpha) are usually considered at that conclusion.

This method of determining the downwash angles is also used in the tests with the screen imitating the ground effect. Downwash angles are known to decrease as the land approaches.

It is possible to estimate the value of the downwash for the flow conditions without a screen using a Glauert method, having calculated preliminary the distribution of the circulation over the wingspan. According to the approximate method of Glauert the vortex sheet of a wing is substituted by horseshoe vortex, which creates a downwash at the location of h.t. at small distances from the symmetry plane of the wing. This downwash is equal to

$$\varepsilon = \frac{\overline{\Gamma}_0^2}{2\pi AR}\left[1+\sqrt{1+1/\left(\overline{\Gamma}_0^2 * \overline{L}^2_{h.t.}\right)}\right] * CL \quad (1)$$

where AR - is the wing span, $\overline{L}_{h.t.}$ – is the non-dimensional distance between aerodynamic wing focuses and h.t., in the units of half wing span; the non-dimensional value of the wing circulation at the side section of the wing is considered as Γ_0, which provides the satisfactory convergence of computed and experimental results, CL is the lift coefficient of the wing. I.e. the linear dependence of downwash flow on the lift coefficient of the wing follows from the approximate method of Glauert.

2. Experimental setup

Experimental measurements of the downwash flow angles were conducted at TsAGI T-102 low speed wind tunnel for the model of the civil aircraft. The aircraft model was done according to the scheme of “low-aircraft” with supercritical wing $\Lambda = 25°$, AR = 8.8, with engine nacelles located at the bottom surface of the wing and with low located h.t. Wing surface was $S_{wing} = 0.35\ m^2$, wing span - 2 m, the average aerodynamic wing chord MAC = 0.25m. Tests were conducted with the flow speed 50m/s ($M=0.15$, $Re=0.9*10^6$) at cruise, and also take-off and landing configuration, when slats and flaps were deviated at the given angles. Angles of attack and angles of h.t. setup were varied at the wide range of values and model position relative to the screen has also being changed. Test results with h.t. and without h.t. on the model allowed to determine the average values of the downwash flow angles at the region of h.t. from the condition $\Delta Cm_{h.t.}$ (alpha, φ) = Cm (alpha, φ) – $Cm_{w/o\ h.t.}$ (alpha) = 0. Distance between the screen and conventional center of gravity h=h/MAC has been held constant during the tests with the screen when angles of attack were varied. Distance from the screen to the aft edge of the wing differed from the cited value of $\bar{h}$ on $\Delta\ \bar{h}=0.75*tg(alpha)$, i.e. on ~ 0 ÷ 0.2 see Fig.1.

Scheme of passangere aircraft model with scrin

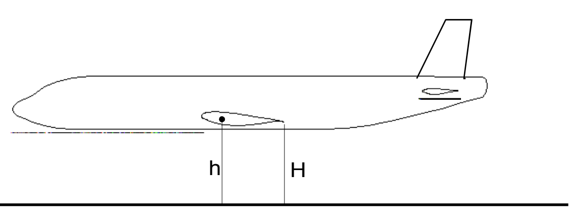


Fig. 1

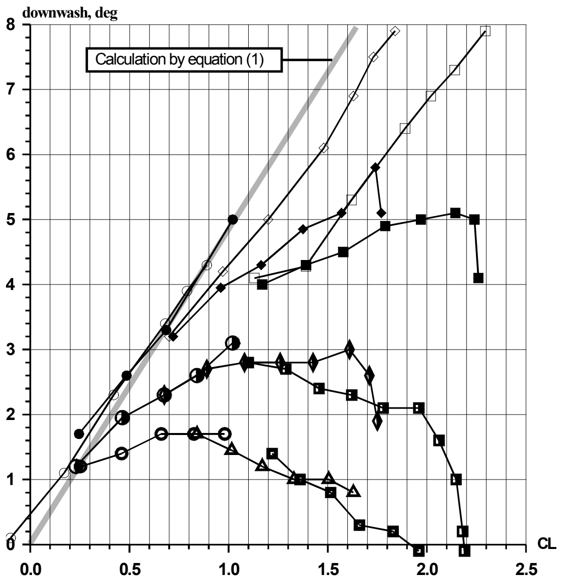
3. Description of the result

Results of the measurements of downwash angles as the function of CL are represented at Fig.2. It is seen that, indeed, all the variety of conditions for all model configurations falls on the dependence $\varepsilon(CL,\ \bar{h})$.

Results of the determination of downwash angles $\varepsilon(alpha,\ \bar{h})$ are shown at Fig.3. It is seen that they considerably depend on alpha, $\bar{h}$ and model configuration.

Downwash angles for the cruise regime out of the screen agree well with the results computed using the relation (1) cited above for the values $\Gamma_0 = 1.45$, $\bar{L}_{h.t.} = 1.0$ characteristic for the civil aircrafts.

T-102 wind tunnel, full model M = 0.15 Re = 0.9 mln



	without screen	$\bar{h}=2.82$	$\bar{h}=1.67$	$\bar{h}=1.1$
Cruise configuration	○	●	◑	○
Take off configuration	◇	◆	♦	△
Landing configuration	□	■	◧	▣

Fig. 2

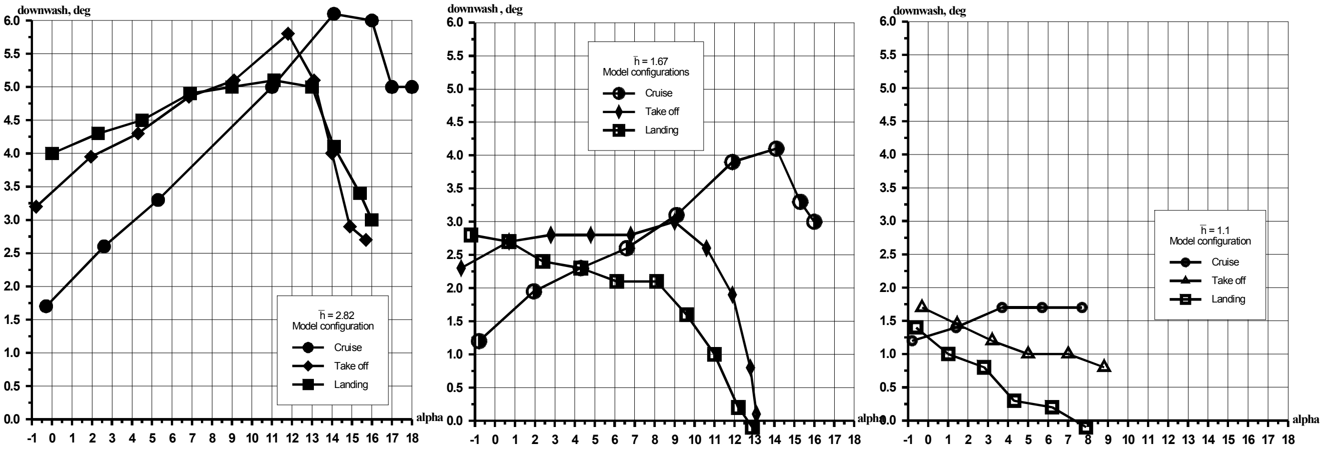


Fig. 3, T-102 wind tunnel M = 0.15,
Re = $0.9*10^6$

4. Conclusion

In this paper shown that the all the variety of conditions for all model configurations falls on the dependence ε(CL, $\bar{h}$).

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6. References

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