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COMPARISON OF THE LAMINAR-TURBULENT TRANSITION PREDICTION USING DIFFERENT METHODS WITH THE LAMINAR WING TEST RESULTS

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When designing the laminar airplane, particularly important are issues related to the free-stream turbulence effects and the extrapolation of the test data, obtained in industrial wind tunnels (WT), to flight conditions.

In connection with this, it is very important to verify different methods of the boundary layer stability and laminar-turbulent transition prediction by comparison of the CFD and experimental data. In particular, a special interest is shown in the definition of the calculated N-factor values, corresponding to the laminar-turbulent transition in test conditions at different initial turbulence levels.

Nowadays, the CFD-methods basing on the Reynolds-averaged Navier-Stokes equation solutions are widely used. These equations are closed using the semi-empirical turbulence models, with some of them being able to predict in principle also the laminar-turbulent transition characteristics. However, additional researches are demanded to define the operational limits of the existing turbulence models, to compare different models and to develop recommendations for their practical use.

The proposed study is the continuation of the researches completed in TsAGI in the framework of the TELFONA project [1] (6th European FP). It is devoted to investigation of the possibilities to implement different calculation methods to the laminar-turbulent transition prediction and the influence of higher disturbance background level on its characteristics.

To analyze these effects, the detailed experimental studies of transition zones on the straight and swept wing (leading edge sweep angle 35˚) with laminar profile LV6 were carried out in the low-turbulence TsAGI T-124 wind tunnel. Both models had chord and span equal to 1m, possessing to obtain the Reynolds number of 5.4-5.5 million at flow velocity about 80 m/s.

The investigations were performed of the incoming flow turbulence and acoustic disturbances effects on the laminar-turbulent transition. To increase the incoming flow turbulence level special turbulizing grids were used. Both the time-averaged and unsteady flow components in the boundary layer were measured using the constant-temperature thermoanemometer with a single hot-wire sensor.

In the proposed report the results of such an analyses for straight wing are presented.

The laminar boundary layer stability characteristics in the test conditions were calculated using the method [2], based on the linear hydrodynamic stability theory. These data were compared with the experimental results. The N-factor values corresponding to the experimental transition position (N_{tr}) at different levels of the incoming flow turbulence and acoustic disturbances were obtained.

Implementation of the modern turbulence models, such as the Langtry-Menter [3] and Walters-Cokljat [4] ones is also investigated for the wing flow calculation in the WT conditions. The problems associated with the WT mathematical model elaboration are considered separately. Comparison of the calculated and experimental data showed that using the Langtry-Menter model it is possible both to define with the satisfactory accuracy laminar-turbulent transition zone for different values of the incoming flow turbulence levels and to predict other flow parameters (wing pressure distribution, boundary layer velocity profiles, etc.)

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