11th. World Congress on Computational Mechanics (WCCM2014)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

SPECIAL TECHNOLOGICAL SESSION (STS05)

TRANSITION LOCATION EFFECT ON SHOCK WAVE BOUNDARY LAYER INTERACTION

ORGANIZER: PIOTR DOERFFER

Title of the Presetation: Computational Investigations on Correlation between Laminar-Turbulent-Transition Location and Buffet Onset

Authors:

[*] Katarzyna Surmacz, Institute of Aviation ,
Al. Krakowska 110/114,02-256 Warsaw, Poland,
katarzyna.surmacz@ilot.edu.pl, ilot.edu.pl

[†] Wieńczysław Stalewski, Institute of Aviation ,
Al. Krakowska 110/114,02-256 Warsaw, Poland,
stal@ilot.edu.pl, ilot.edu.pl

Janusz Sznajder, Institute of Aviation ,
Al. Krakowska 110/114,02-256 Warsaw, Poland,
jsznaj@ilot.edu.pl, ilot.edu.pl

Key words: natural laminar flow, transonic flow, laminar-turbulent transition, buffet onset

ABSTRACT

Natural-Laminar-Flow (NLF) technology is widely investigated from the point of view of application in civil transport because of expected profits in drag reduction. However in transonic regimes there occurs risk of harmful interactions between laminar boundary layer and shock wave which is usually considerably more intensive for laminar flow than for turbulent flow. As an effect, the benefits associated with application of the NLF technology on the transonic wing due to decrease of friction may be cancelled by considerable increase of wave drag. Additionally, as an effect of detrimental interactions between the laminar boundary layer and the shock wave the safety margin for off-design conditions, limited by buffet onset is decreased. The occurrence of shock wave buffet phenomenon – extremely unsteady, self-sustained shock wave / boundary-layer interaction is dangerous to flight safety and should be avoided in flight operations.

For this reason, in order to fully exploit the profits offered by the NLF technology on transonic wings investigations are conducted focusing on shock wave – boundary layer interactions and on possible solutions of mitigating the harmful effects, mentioned above. One of such solutions is enforcing laminar-turbulent transition of flow before the possible location of the shock wave. Among other works, the TFAST (Transition Location Effect on Shock Wave Boundary Layer Interaction) project is concentrated on this subject. In the TFAST project several approaches of enforcing of laminar-turbulent transition in front of shockwave region are investigated, including locally increased roughness or the effects of sub-layer vortex generators.

The present paper was prepared as an effect of realisation of one of the work packages in the TFAST project, devoted to the study of transition location effect on separation size, shock structure and unsteadiness.

The final paper will be focused on computational investigations of correlation between laminar-turbulent-transition location and buffet onset. The investigations were conducted using ANSYS FLUENT solver which was used to solve URANS equations with 4-equational turbulence model Transition SST. The model is based on the coupling of the SST k-w transport equations with two other transport equations, one for the intermittency and the second one for the transition onset criteria, in terms of momentum-thickness Reynolds number. An ANSYS empirical correlation has been developed to cover standard bypass transition as well as flows in conditions of low free-stream turbulence.

Presented in the paper URANS simulation concerned the flow around the model of laminar-transonic airfoil being the baseline in the TFAST project. In the simulations instead of farfield-type boundary conditions, a real environment specific to planned wind tunnel tests of the airfoil has been modelled. To catch the buffet onset phenomenon, the unsteady flow through the test chamber with mounted model of airfoil, with time-increased free-stream Mach number was investigated. The assumed buffet onset criterion was based on analysis of fluctuation of pitching moment coefficient of the airfoil. The typical obtained changes of the pitching moment as a function of time-increased Mach number are presented in Figure 1. The described simulations, aiming at computational assessment of the Mach number of the buffet onset, were conducted for both the natural laminar-turbulent transition and the transition forced at assumed location in front of expected shock-wave appearance.

In the final paper the complete analysis of obtained results will be presented as well as the conclusions about the correlation between laminar-turbulent-transition location and buffet onset on investigated model of airfoil will be formulated.

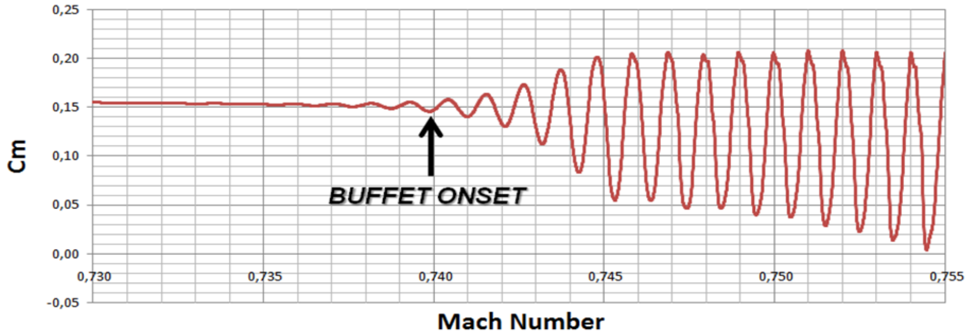

Figure 1. Dependency of pitching-moment coefficient vs. time-variable Mach number analysed to assess the buffet onset.

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