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Prediction and Experimental Validation of Buffeting Phenomena

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ABSTRACT

Transonic buffeting flow phenomena may occur in many aeronautical applications ranging from internal flows such as around turbo-machinery blades to flows over aircraft. This type of flow is characterized by a self-excited periodic 180^0 out-of-phase motion of the shocks over the upper and lower surface and causes oscillations in the global aerodynamic forces [1]. Unsteady shock/boundary-layer interaction (SWBLI) affects drastically aerodynamic performance and is a potential major threat for overall safety. The capability to accurately predict such phenomena is of technological significance in experimental facilities (wind tunnels) and a real challenge for current state of the art computational platforms. (Figure 1 – buffeting experiment in INCAS supersonic wind tunnel schlieren pictures using colored filter normal to the flow).

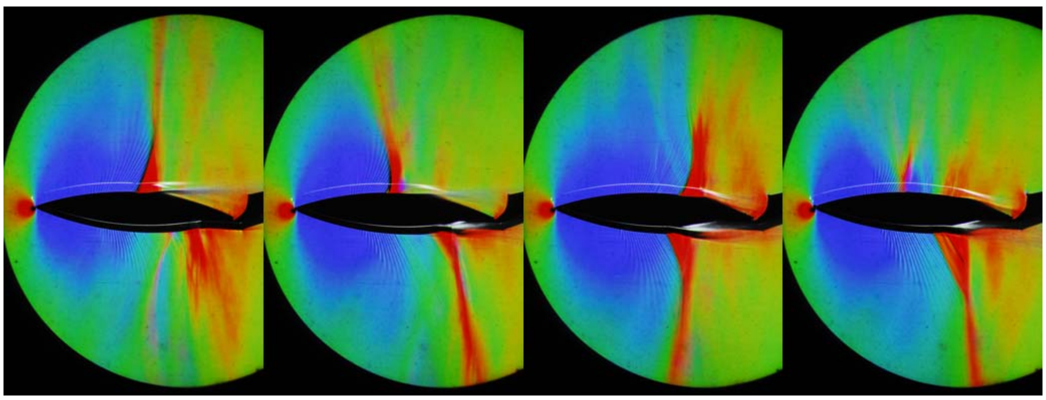

Figure 1 : Schlieren pictures for 18% biconvex, 1 deg., Mach 0.762, Reynolds 8 mil.

The capability for controlling the buffeting phenomena needs extensive knowledge related to the SWBLI mechanisms, combined with the requested technology for active flow control. The use of flow control devices such as synthetic jets (SJ) has the capability for such type of control. The usage of this type of technology is possible due to the progress achieved through complex numerical simulations [3] combined with experimental wind tunnel investigations.
A typical computation for the biconvex 18% aerofoil using the geometry of INCAS supersonic wind tunnel with solid walls test section is presented in Figure 2. This simulation is performed on a 3D geometry using DxUNSp CFD code developed by the

authors [3], and results are presented for a reference cross section at 40% spanwise location. For a particular configuration at Mach 0.75, Reynolds 11 mil. and 3.5 deg. incidence, the computed reduced frequency for the buffeting oscillation was 0.455, somehow very close to the experimental values presented in [2].

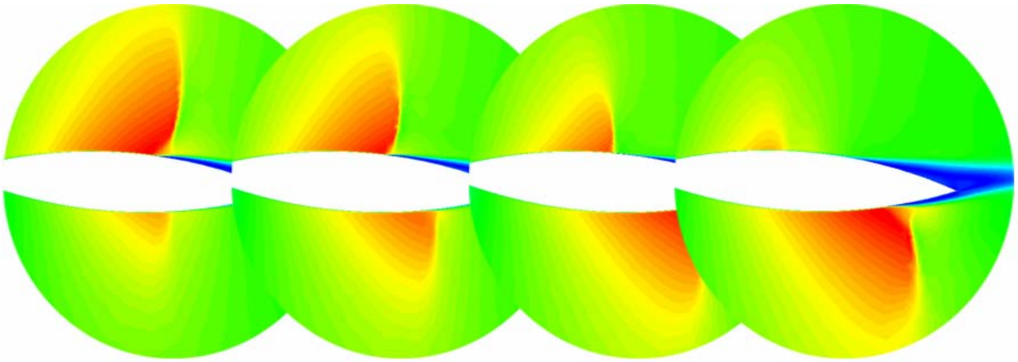

Figure 2 : URANS simulations for 18% biconvex, 3.5 deg., Mach = 0.75, Reynolds = 11 mil.

Complex experiments with the aim of showing the potential of SJ for buffeting alleviation have been performed at INCAS Supersonic Wind Tunnel (Figure 3). The experiments were designed in order to enable buffeting on the model; buffeting was identified using schlieren images for qualitative analysis. SJ control was then applied for this flow configuration

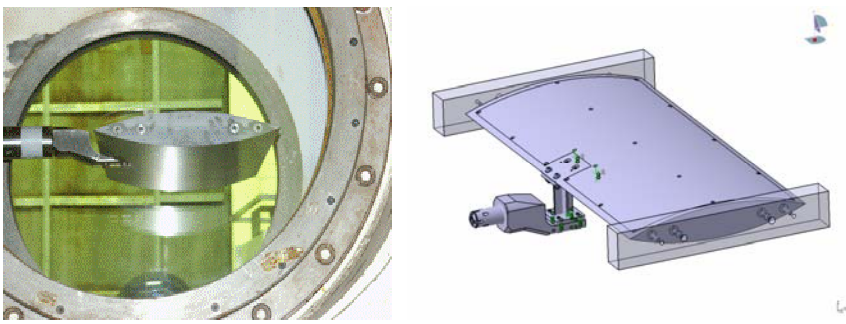

Figure 3 : Wind tunnel experiments for buffeting

This work was performed with relation to the EU FP6 project UFAST. The major goals of this project are related to a higher and deeper understanding of the mechanisms of SWBLI, where buffeting flows are considered as one of the selected relevant phenomena. The usage of the advanced numerical techniques were considered in strong correlation with detailed experiments using state of the art tools and instruments.

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