International Conference on Instability and Control of Massively Separated Flows - ICOMASEF
Monash Centre, Prato, Toscana, Italy, September 5-6, 2013

Characterisation of the transient dynamics of a controlled separated flow using phase averaged PIV

C. Raibaudo[1,2], F. Kerhervé[1,2], C. Cuvier[2], M. Stanislas[1,2]
[1]Ecole Centrale de Lille, [2]Laboratoire de Mécanique de Lille
Boulevard Paul Langevin, 59800 Lille, FRANCE

Abstract

Transient dynamics during reattachement and separation of a turbulent boundary layer flow under the effects of pulsed fluidic actuators are examined in details. The objective of the overall work is to depict the dynamics of the flow during these two processes in the context of flow control and design of model based control strategy. Particular attention will be here focussed on the time delays characterising both the reattachement and separation phases.

Experiments are conducted in the LML boundary layer wind tunnel. The flow developing over the ramp described in figure 1 is considered. Of interest is the decelerating boundary layer on the articulated flat plate which naturally separates at the sharp edge. At the separation point, the boundary layer thickness is about 20 cm. An array of pulsed co-rotating jets vortex generators, covering the entire spanwise extend of the wind tunnel and located upstream of the separation region, is used for flow control. The jets are blowing upstream, at 45° to the wall and to the streamwise direction. The diameter, spanwise spacing and blowing angles of the jets are chosen based on the optimal configuration (in terms of reattachement) found by Cuvier [1]. Festo valves are used to actuate the pulsed jets.

A parametric study is conducted where the velocity ratio (VR), the frequency (f) and the duty cycle (DC) are considered. These parameters may be seen as the input variables of an open-loop control system. A 2D2C PIV system is used to investigate the flow field over the separation region. In addition, a hot-film sensor located downstream of the separation edge is used to give indication on the flow state on the ramp (separated or attached). In order to characterise in details the development of the attachment and separation processes (spatial organisation and time scales), a phase-averaged survey is implemented: the actuation is operated repetitively and PIV data are recorded in phase. Figure 2 gives a sample of the averaged hot-film response in the pulsed jet case corresponding to f = 10Hz, DC = 50% and VR = 4, together with the actuators and PIV synchronization signals. This is done for different values of the control parameters. Figure 3 shows three phase averaged streamwise velocity maps during the attachment process corresponding to the case shown in figure 2.

Detailed analysis of the phase-averaged flow field will be presented and results of the open loop test will be discussed. Special attention will be given to the identification of the specific times which characterise the reattachement and separation processes required to establish accurate models of the flow response to actuation.

Cuvier C. (2012) Contrôle actif du décollement d’une couche limite turbulente en gradient de pression adverse, *PhD Thesis Ecole Centrale de Lille, N°189*

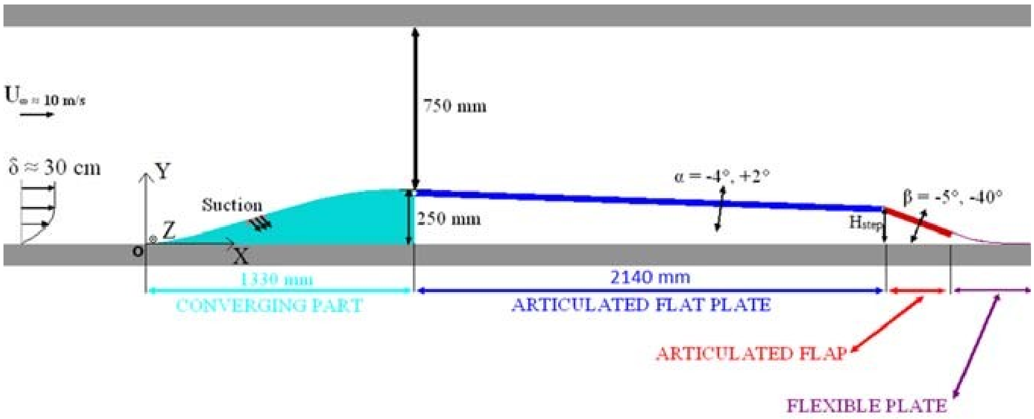

Figure 1: Schematics of the two-dimensional ramp in the LML boundary layer wind tunnel.

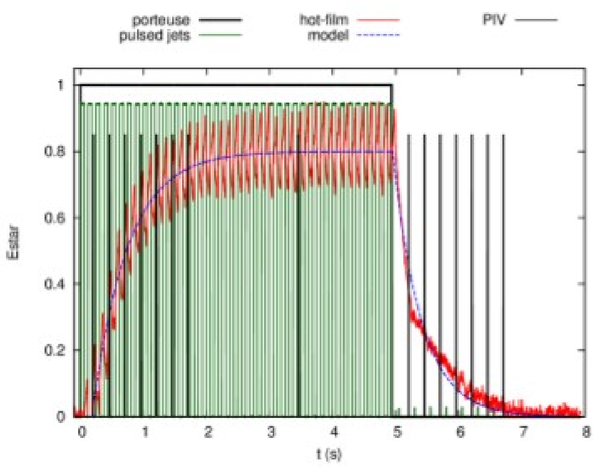

Figure 2: Averaged hot-film response with (green) actuation signal, (black vertical lines) PIV snapshots, (red) averaged hot-film signal, (blue) first-order model.

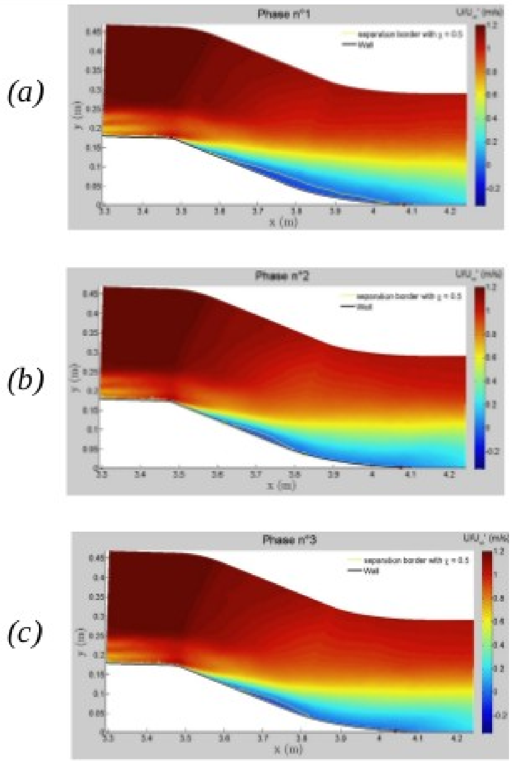

Figure 3: Mean streamwise velocity component at the three first phases during reattachment period.