European Drag Reduction and Flow Control Meeting – EDRFCM 2015
March 23–26, 2015, Cambridge, UK

CONTROL OF CAVITY-INDUCED DRAG USING STEADY JETS

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INTRODUCTION

Separated shear layer oscillations in open cavities can induce drag, noise and vibration. This issue has many aerospace applications such as Landing gears and control surfaces [1]. Recently, phase-cancellation [1] and off-instability frequency excitation [2] & [3] approaches have been incorporated in different open-loop and feedback control systems. Despite the high control performance of these systems, further enhancement is still possible.

In this study, steady jets, as shown in fig. 1, are forced through 2mm, two-dimensional slots at the leading and trailing edges of the cavity. In order to study the performance of this novel approach, different cases will be examined, including: jet combination (blowing from cavity leading edge, suction from cavity leading edge and blowing-suction), jet angle (parallel or deflected jet) and jet-to-free stream velocity factorU_{jet}/U_{∞}.

Experimental Set-up

The cavity model is made from plywood. The depth (D) and the width (W) of the cavity are 65mm and 800mm respectively, while cavity length over depth ratio (L/D) is 4. Experiments are carried out at a free stream velocity U_{∞} of 26 m/s.

The general topology of the flow field has been examined using 2.5 Hz repetition rate Particle Image Velocimetry (PIV). The unsteadiness of the shear layer has been studied using hotwire anemometry and three SensorTechnics HCL0050E pressure transducers. These pressure transducers are mounted at the cavity floor. These transducers have a response time of an order of micro-seconds which is much smaller than the time scale of the fluctuating frequency of the cavity flow. The three-dimensional effect has been examined via surface oil flow visualisation. Crosswire Anemometry will be used to characterise the jets.

Preliminary Results

To obtain preliminary results, the time-mean velocity field was examined by averaging 700 images from 2.5 Hz repetition rate Particle Image Velocimetry (PIV). The images were cross-correlated using adaptive interrogation area (64x64 pixels with 1 pass to 32x32 pixels with 2 passes, 50% overlap). On other hand, a handheld anemometer was used to roughly estimate the jet velocity. Fig.2 shows the mean flow field contour of the streamwise velocity component for the baseline and a control case (Blowing from leading edge at U_{jet}/U_{∞}=0.1, parallel jet).

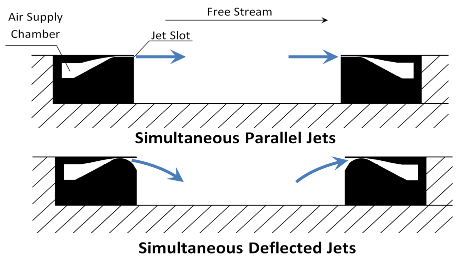

Figure1: The proposed control method.

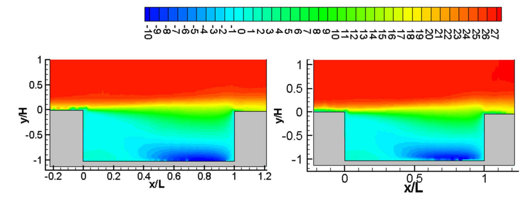

Figure 2: Mean flow field contour of the streamwise velocity component (m/s) at $U_{\infty} = 26\ m/s$: left hand side: Baseline , right hand side: Blowing from leading edge at U_{jet}/U_{∞}=0.1 (parallel jet).

The figure indicates no noticeable impact on the separated shear layer time-mean velocity field for this control case. However, the time-mean velocity fluctuation (indicated by RMS values) in the separated shear layer for the same control case has increased significantly. This is perhaps due to the interaction between the separated shear layer and the parallel jet.

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