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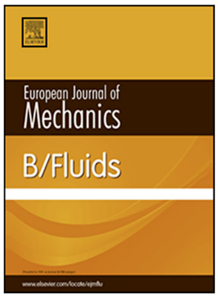

Hydrodynamic oscillations inside deep cavities with wall offset

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Hydrodynamic oscillations inside deep cavities with wall offset

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Abstract The paper focuses on the pressure amplitude response of deep cavities at low Mach numbers with wall offset between the leading and trailing edges. Three wall offsets of $d/h = -10.75\%$, 0.00% and $+10.75\%$ are considered for different Reynolds numbers and values of length-to-depth ratio (l/h=0.24, 0.48 and 0.65). Present experiments show that for deep cavities, oscillations of discrete frequencies can be produced even in configurations with wall offset. Convection velocity along the shear-layer, measured using velocity cross-correlations, exhibits clear l/h and d/h dependencies which suggests that the original Block's model, which predicts the dominant frequencies, should be revisited to take into account for wall-offset distances. For wall offset of $d/h = -10.75\%$, a significant attenuation of the pressure oscillation has been observed while for cases with $d/h = +10.75\%$, the pressure oscillation frequency peaks is shifted compared to the reference case without wall offset.

Keywords Convection velocity, cavity flow, hydrodynamic modes, Rossiter model, velocity correlations, wall pressure measurements

1 Introduction

Cavity flow is a very studied configuration, mainly due to its omnipresence in numbers of transport systems, including aircraft landing gear wheel wells, car sun roofs and the gap between train wagons, but also in gas transport systems ([29],[30]) to give only few examples. The main feature of this type of flow is the ability to produce some acoustic disturbances at high Reynolds numbers [23]. In the literature, three types of cavity can be distinguished depending on the reattachment point of the shear layer; the so-called open, closed and transitional cavities. A cavity is said to be opened when the reattachment point takes place near the downstream edge, and closed when the reattachment point is located on the floor of the cavity. If the two states occur randomly in time, the cavity is said to be transitional. Open cavities occur for low length-to-depth ratios (typically $l/h < 8$), closed cavities occur for large l/h ratios ($l/h > 12$) and transitional cavities occur for the middle values between the ratios for the open and closed cavities. For the open cavities, we can speak about "deep" cavity when $l/h < 1$ [9] otherwise we can qualify the cavity by "shallow" [24]. The flow for resonant open cavities is governed by a feedback mechanism between the shear layer instabilities and acoustic disturbances ([10],[28],[27],[26]). One of the main contribution to explain this phenomenon over rectangular cavities, is given by Rossiter [4]. The feedback mechanism can be described as followed; a vortex is formed in the cavity shear-layer and involves downstream from the cavity leading edge and impinges onto the other side wall of the cavity, causing an acoustic pressure wave, which travels upstream and triggers Kelvin-Helmholtz instabilities at the origin of a new vortex shedding. The corresponding empirical Rossiter formula classically used in the literature ([11],[4],[7],[8]) can be expressed as follows:

$$St = \frac{f.l}{U_\infty} = \frac{n - \alpha}{M + 1/\kappa} \qquad (1)$$

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