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SUPERSONIC FLOW OVER CAVITIES : A FEW THERMO FLUID DYNAMIC ASPECTS

JOB KURIAN, *Indian Institute of Technology,Madras India*

Research and studies on supersonic flow over wall mounted cavities have been carried out extensively in the past decade. Earlier studies on flow over cavities were aimed at studying the self sustained oscillations which are the source of flow noise and undesirable structural loading. In the current decade, attention is drawn on the flow over cavities due to the possible role of the cavity oscillations for fuel-air mixing and flame holding in supersonic combustors.The present paper consolidates a part of the work on cavities carried out in the Gas Dynamics Laboratory of Indian Institute of Technology, Madras, India. The paper gives details of the results of studies on the scaling effect of cavities, effect of aft-wall and flow path floor modifications of the cavity, active control of the oscillations generated by the cavity and also the results of numerical estimate of the entrainment in to the cavity .

The experiments were done on the wall mounted cavities of the configurations given below:

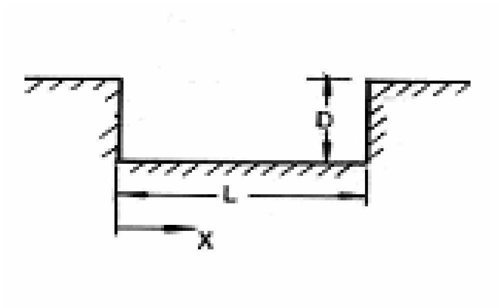


Fig. 1 Rectangular cavities
L = 50, 70 and 90mm, L/D : 1.8, 3, 6, 9 and 14

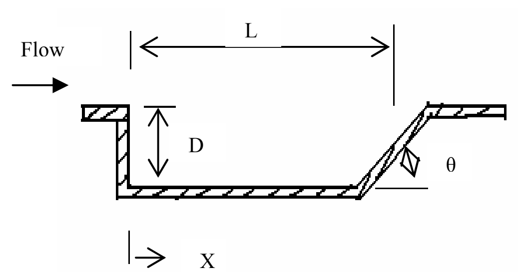


Fig.2 Cavity aft wall modification

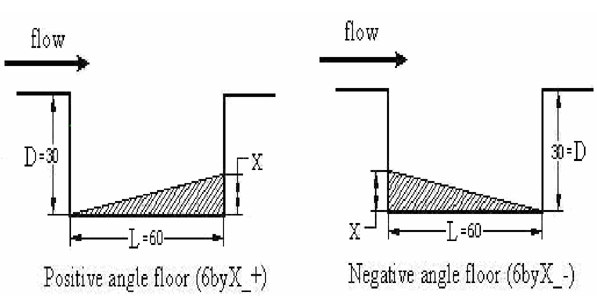


Fig.3 Cavity with floor modification

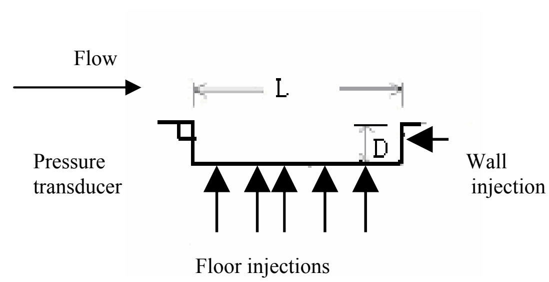
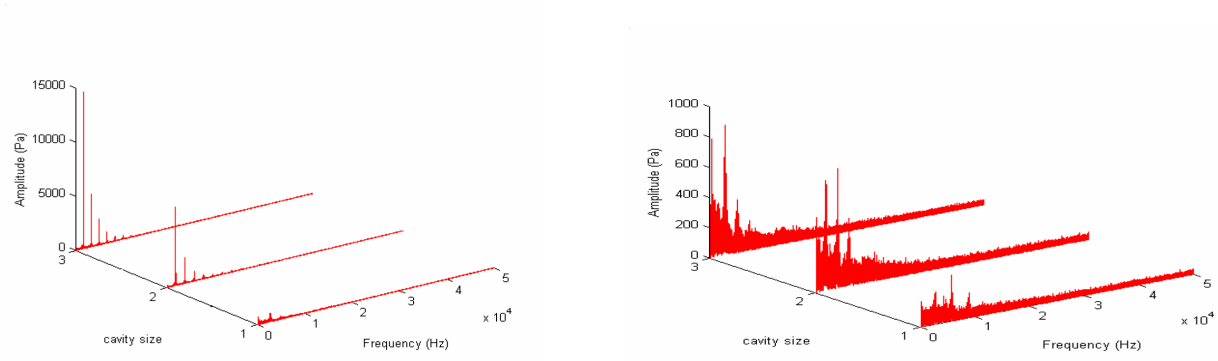


Fig.4.Cavity injection for flow control

The nominal free stream Mach number in the experiments is ~1.7 to 2.0. Measurements undertaken were of static and Pitot pressure, unsteady and acoustic pressure . Flow visualization using schlieren gave insight in to the wave and flow structure. Typical results on a few of the aspects of study are given here. It is well known that the amplitude of pressure oscillations generated by the cavity depends on the cavity geometry and on the free stream Mach number. One of the aspects of study included in the paper is the investigation in to the scaling effect of the

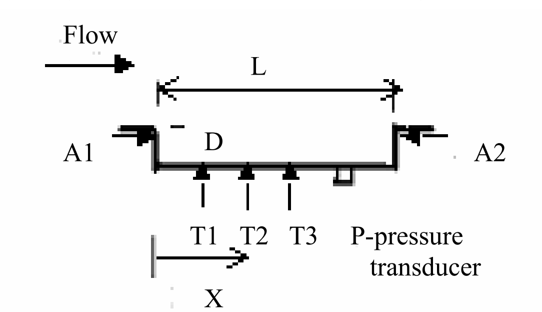


L/D =1.8 **L/D = 6**

Fig. 5 Acoustic signature containing the dominant peak for different cavities
(cavity size1: 50mm, cavity size 2: 70mm, cavity size 3: 90mm)

cavities. Fig.5 gives comparison of acoustic signature obtained from with in the cavities of similar L/D ratio but of different dimensions. As the L/D ratio is increased, the amplitude of acoustic oscillation decreases. Also, as the size of the cavity is increased the amplitude of oscillation is decreased. The effect of size of the cavity for the same L/D ratio is evident from Fig.5.This could be considered as a consequence of change in size of the vortex inside the cavity. This and a good number of similar results on scaling effect lead to the conclusion that the acoustic energy stored in the cavity depends on the cavity volume.

Typical results from aft wall modification of the cavity show that low ramp angles give rise to lower amplitude of oscillation. This indicates the potential of such cavities for flame holding application, though the higher values of cavity drag from such cavities is a matter of concern. Active control of cavity performance can be effected by cavity based injections from floor and wall ports with out modifying the cavity geometry. Some results of cavity based injection in to the free stream are given here.



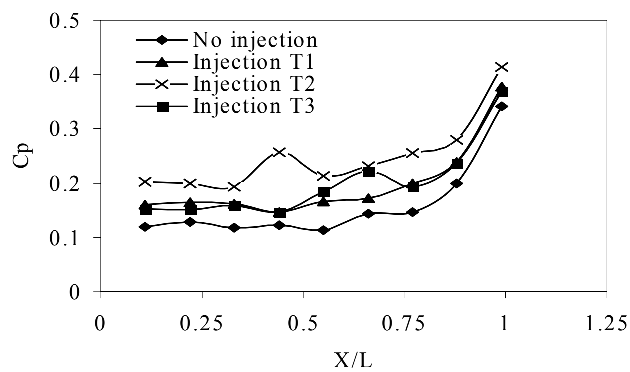


Fig. 6 Details of cavity configuration showing different injection locations

Fig. 7 Cavity floor pressure distribution(Cp) with injection

Injection is done from the three floor locations T_1,T_2 and T_3 .They are provided to inject the gaseous fuel well in to the free stream with sufficient jet pressure. As the jet encounters the free stream, a part of it could be diverted in to the cavity and could increase the cavity entrainment. The pressure distribution inside the cavity is seen to be modified with the injection. The Figure7 gives cavity floor pressure distribution for the maximum injection pressure of 7.7bar.Injection from all the locations increases the pressure level inside the cavity indicating entrainment of additional fluid in to the cavity. These results are corroborated with schlieren pictures.

More results on these aspects and on others such as the effect of cavity floor modification will be presented in the full length paper.