

Bleed System for Safe Release of Weapons from Combat Aircraft

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Abstract: An idea was carried out on an open cavity having a free stream Mach number of 0.8. The main objective of the present study is to design a passive venting that connects the high pressure region on the rear wall to a low pressure region downstream of the cavity. The baseline condition shows that the cavity flow oscillate with the total amplitude of 155 m. The vortex clipping which is responsible for the self-sustained nature of the cavity flow and the corresponding time history of the pressure on the cavity rear wall is discussed. A cross correlation analysis was carried out between the pressure history at the points on the rear wall of the cavity and the ones on the wall downstream of the cavity. Two points that defines the passive venting were identified based on the rear wall Overall Sound Pressure Level (OASPL) and the minimum time lag computed by cross correlation. The venting is shown to reduce the cavity oscillations and the rear wall pressure is shown to reach a steady state value which is desired in the perception of low cavity noise that can be used to reduce the structural loads and the acoustic loads on electronic components kept near the cavity.

Keywords: Bay, Cavity, Combat, Venting.

I. INTRODUCTION

Cavities generally exist in the form of landing gear wheel well (Fig. 1) and weapon bay (Fig. 2) in air crafts. The grazing flow over the cavity tends to produce high magnitudes of oscillation at a frequency that depends on so many factors such as cavity dimensions, free stream Mach number, boundary layer status at cavity leading edge. The separated shear layer from the leading edge grows and the disturbances are amplified due to Kelvin Helmholtz instability, and the shear layer is wrapped into vortices as shown in (Fig. 3) and the unsteady impingement of the shear layer on the rear wall produces pressure waves that travels inside the cavity toward leading edge. Upon reaching the leading edge, the pressure wave energies the leading edge and completes the feedback loop which leads to self-sustained oscillations (Fig. 4). Without control this high amplitude self-

sustained oscillations (Up to 170 dB) (Fig. 5) can damage the sensitive electronic equipment or can affect the weapon release from the air craft (Fig. 6). The noise radiated from the cavity need to be controlled. Among passive, open and closed active control techniques, passive control has the advantages over other control techniques in the form of simple, easy to install and maintain. They don't need any external energy input. This study aims to apply bleed near trailing edge to relieve the higher unsteady pressures. The schematic of the bleed is shown in Fig. 7. The configurations will be tested at a free stream Mach number of 0.8.



Fig. 1: Wheel Bay of an Aircraft



Fig. 2: Wheel Bay of an Aircraft

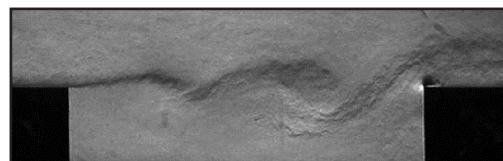


Fig. 3: Schlieren Image of Flow over Cavity

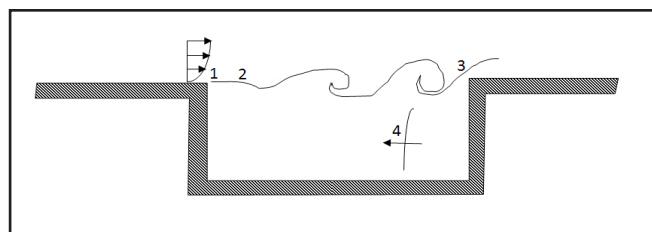


Fig. 4: Schematic of Flow over Cavity

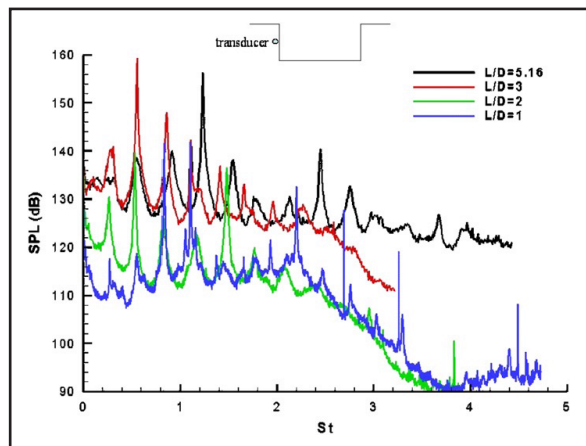


Fig. 5: Schematic of Flow over Cavity

II. METHODOLOGY

In this chapter we present a methodology that uses in our project on “Bleed system for safe release of weapons from combat aircraft”. At the beginning of the chapter, motivation for present methodology is discussed. And some other preliminaries are also added in the next sections. Finally, the main cause of the pressure wave formation is discussed in the last section.

A. Analysis Using ANSYS Modelling

The ANSYS Mechanical software suite is trusted by organizations around the world to rapidly solve complex structural and thermal problems with ease. Structural mechanics solutions from ANSYS provide the ability to simulate every structural aspect of a product, including nonlinear static analysis that provides stresses & deformations, modal analysis that determines vibration characteristics, through to advanced transient nonlinear phenomena involving dynamic effects & complex material behavior.

B. Kelvin Helmholtz Instability

The theory predicts the onset of instability and transition to turbulent flow in fluids of different densities moving at various speeds. Helmholtz studied the dynamics of two fluids of different densities when a small disturbance, such as a wave, was introduced at the boundary connecting the fluids. For some

short enough wavelengths, if surface tension is ignored, two fluids in parallel motion with different velocities and densities yield an interface that is unstable for all speeds. Surface tension stabilizes the short wavelength instability however, and theory predicts stability until a velocity threshold is reached. The theory, with surface tension included, broadly predicts the onset of wave formation in the important case of wind over water.

C. Cavity Geometry

The discussion is first restricted on rectangular cutouts. The length of the cavity is Denoted L,D is its depth, and W represents its span wise width.

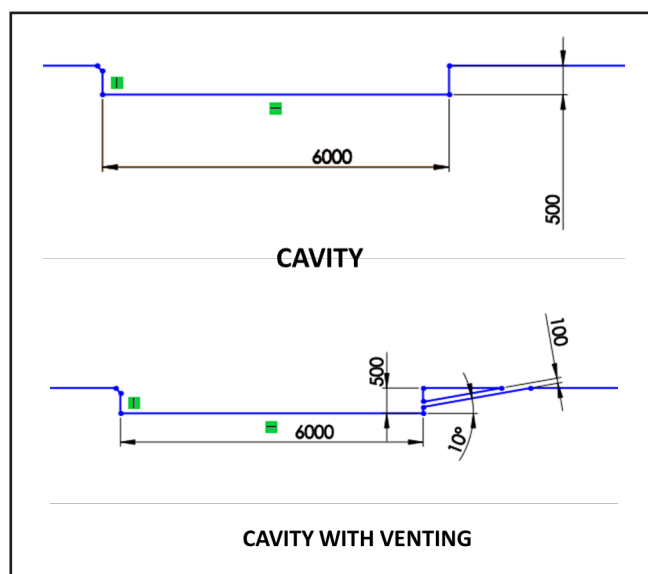


Fig. 6: Sketch of Cavity Flow

III. RESULTS AND DISCUSSIONS

In this chapter, we discussed about the definition of cavity, need of cavity, working principle, applications of cavity flow. The problems due to cavity flow is also discussed in this chapter. Then reduction technologies are also discussed in this chapter. Here we include the methods of weapons release and the problem occurs due to the release of the weapons from weapon bay cavity flow effect. Therefore, we use an additional ventilation system which will reduces the noise and turbulence flow over the cavity. So far we also added the advantages and disadvantages of the cavity in weapon bay and make analysis to reduces the problems.

A. Cavity

Cavity is a groove on a flat surface. This system is generally used in stealth aircraft for carrying the weapons and landing gears inside the aircraft which gives the less drag and less radar signature.

B. Problems in Cavity

When weapons are released from the weapon bay due to the unsteady of flow the weapon can come back and hit the parent aircraft. This cavity makes more noise and more vibration which can cause damage to the electric equipment and sensors used near the weapon bay. Due to unsteady flow at the weapon bay the released weapons may point towards the parent aircraft which is very dangerous and need to be controlled. Pitching moments included on the store altering its dropping trajectory which cause the longitudinal pressure gradient problems. There are many methods to control this but those are very complicated and costlier. So, we decided a new method to implement in it and avoid these problems in cheap and easy way.

C. Weapon Bay Aerodynamics

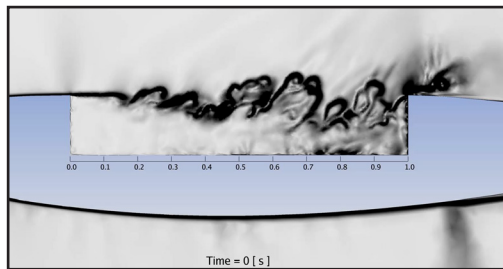


Fig. 7: Flow Field on the Cavity

Following two types are the control techniques;

- *Active Control Method*

In this type of method generally we use spoilers, blowing techniques etc. by using this we can manage the flow unsteadiness and can control the flow as well. In which the trajectory of the shear layer and diverting it outside the cavity.

- *Cavity Shaping*

In his type of methods, we generally use the following methods:

1. Alteration of incoming boundary
2. Slanted walls

In these types we aimed to alter the status of the shear layer inside the cavity.

D. Cavity Shaping

- *Advantages*

1. Absence of moving mechanism.
2. Good performances outside the design point.

- *Disadvantages*

1. Alteration of cavity shape.
2. Influence on airframe external design.

The recirculation zone induced by the cavity walls can modify the trajectory of the vertical structures in the shear layer. This effect is totally ignored in all the theoretical attempts to model the self-sustained oscillations, but can have a non-negligible influence on the variability of the vortex-corner interactions. Experimental investigations in water by Rockwell and coworkers try to relate the vortex distortion during the impingement and the induced pressure field. The details of the vortex-corner interaction determine the instantaneous pressure field, which can drive the shedding of new vortices, as visualized by Tang and Rockwell.

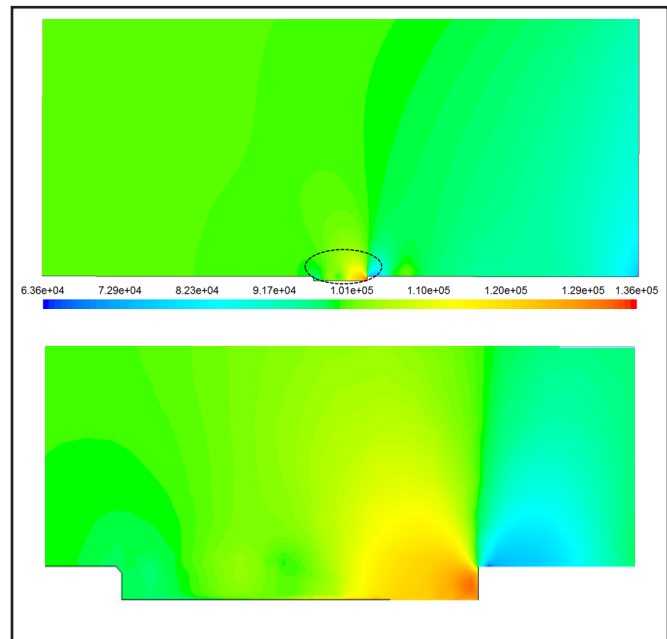


Fig. 8: Static Pressure Contour in Simple Cavity

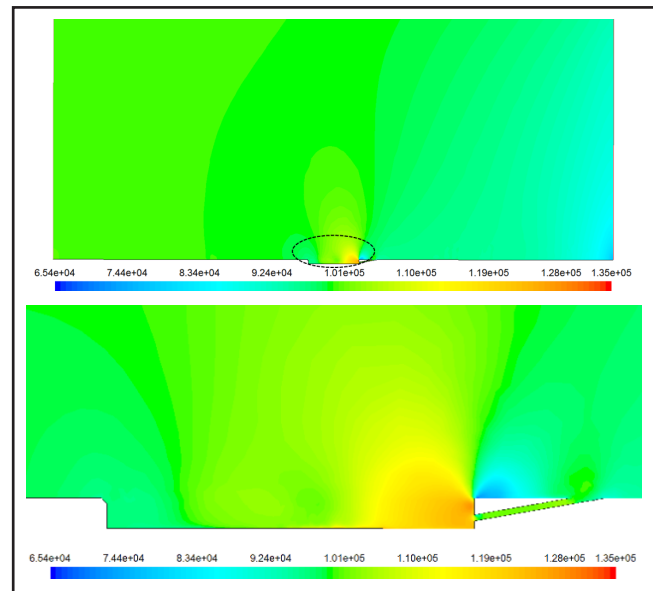


Fig. 9: Static Pressure Distribution of Vent Cavity

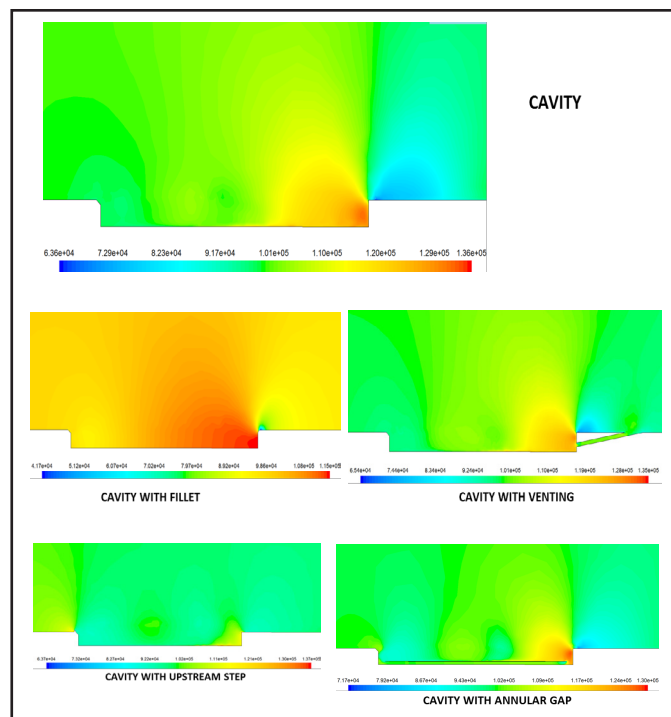


Fig. 10: Comparison between Static Pressure Distribution

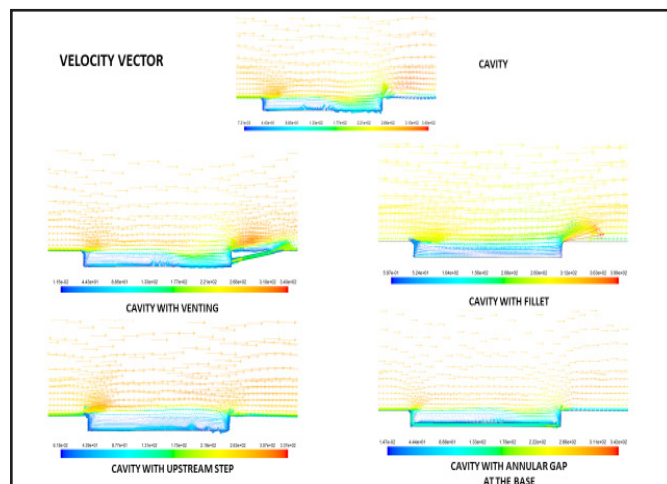


Fig. 11: Velocity Vector

IV. CONCLUSION

The main objective of this work was to design a passive venting that connects the high pressure region on the rear wall to a low pressure region downstream of the cavity. The baseline configuration (without venting) makes the cavity flow to oscillate with an amplitude of 155 m. A cross correlation

analysis was carried out between the pressure history at the points on the rear wall of the cavity and the ones on the wall downstream of the cavity. Sound Pressure Level (OASPL) and the time lag was computed by cross correlation. The venting configuration shows the reduction of the cavity oscillations and the rear wall pressure is shown to reach a steady state value. This causes to reduce the cavity noise. This can be used to reduce the structural loads due to less vibration and the acoustic loads on electronic components kept near the cavity.

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