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Experimental Study of Boundary Layer Effect on the Aeroacoustic Characteristics of the Incompressible Open Cavity

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Abstract

An experiment platform of cavity flow study was built in the low-turbulence wind tunnel. With the method of installing blocks inside cavities, the boundary layer profiles which drag out the shear layer were changed. Averaged static pressure distribution along the centerline on cavity bottoms, and acoustic spectral characteristics of inspected points on cavity wall were obtained from experiments, to discuss the effect of boundary layer profile change under the condition of low-speed incompressible flow on the cavity (long depth ratio were 2 and 4 respectively) aerodynamic and acoustic characteristics. The results showed that, under the velocity of 30m/s, with the boundary layer thickness increasing, the averaged pressure increased with adverse pressure grads decreased, for cavity of L/D=2, the SPL going down in some degree and when L/D increasing to 4, the SPL increased highly in the range of medium to high frequency.

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Keywords: boundary layer; SPL; cavity; shear layer; aeroacoustic characteristics

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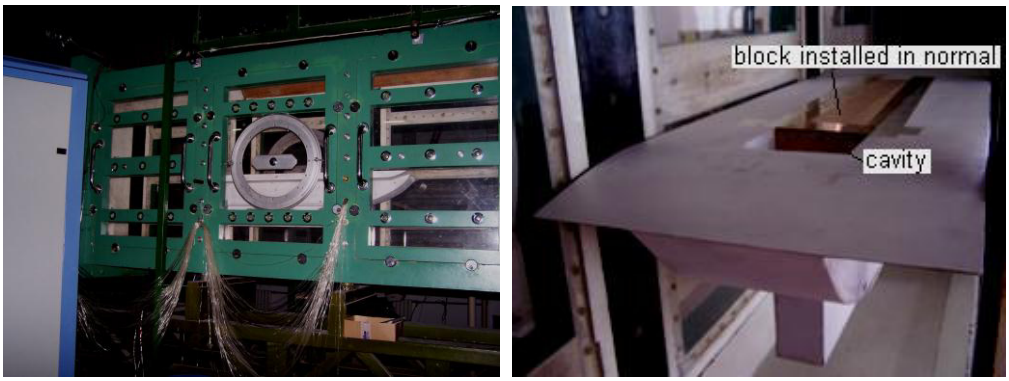
1. Introduction

Oscillation caused by flow over Cavity can increase the drag greatly and even lead to structural vibration and fatigue damage. To identify the oscillation from noise generation mechanism accurately is essential and urgent. For the study of the flow in cavity, since the 1950s, many foreign experimental studies have been carried out. Since the 1980s, numerical simulation is more used in studies related to the mechanism of cavity flow and noise analysis. In China, the study for cavity flow starts only in recent years, and works mainly in the field of numerical simulation for small scale cavity. The aerodynamic center carried on experimental corresponding study of flow characteristics and acoustic characteristics for subsonic and supersonic cavity. Certain research results[1-7] show that the cavity geometric parameters such as length to depth ratio L / D, the aspect ratio W / D, and flow parameters such as Mach number Ma or other effects of the cavity shear layer instability, thereby affecting the flow types and noise spectral characteristics.

When the low speed turbulent flow pass through the rectangular cavity, the flow inside the cavity is very complex, and the pressure spectrum produced by the cavity contains both broad band noise and pure tones. The cavity experimental platform was built in a low-turbulence wind tunnel; conducted experiments to measure the cavity flow noise and to provide validate data for numerical simulation. This article focuses on the effect of changing boundary layer profiles in the cavity inlet on the aeroacoustic characteristics of cavity flow. With the measurement method of wall pressure sensors, microphones and hotwire, based on the open cavity of length-to depth ratio 2 and 4, the inlet boundary layer profile was changed through different block installation methods. The acoustic properties of cavity in different inlet boundary layer flow state were obtained, providing a basis for cavity flow noise suppression research.

2. Experimental model

Open cavity model uses wooden structure. The model blockage degree in wind tunnel test section is about 8%. The maximum depth of the cavity Dmax=116mm, maximum length Lmax=700mm, and the maximum width Wmax=120mm. Cavity model was shown in Figure 1. the contact surface of Model with wind tunnel wall was padding with soft foam to avoid local flow cross up and down, while reducing the effects of wind tunnel vibration on the models flow structure.



(a) two dimensional test section (b) cavity model installed in wind tunnel

Fig.1. Experimental installation diagram