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零质量射流对开式空腔气动噪声抑制效果分析

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Investigation on Suppression Effect of Zero-net-mass-flux Jet on Aerodynamic Noise Inside Open Cavities

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摘要 高速开式空腔流动,腔内存在较复杂的流场结构,在一定条件下腔内存在较为严重的压力、速度等脉动,诱发强烈噪声,声压级(SPL)甚至可高达170 dB,对腔内的储藏物与空腔自身结构安全构成较大威胁,因此开式空腔噪声抑制方法成为争相研究的热点。为此,对跨、超声速流动条件(马赫数Ma=0.9,1.5)下有、无零质量射流时开式空腔(长深比L/D=6)气动声学特性进行了较详细地分析,并通过综合对比分析空腔底面中心线上的声压级分布和不同测点的声压频谱(SPFS)特性,探讨了不同零质量射流方式对空腔气动噪声的抑制效果。研究结果表明,跨声速(Ma=0.9)条件下,采用的零质量射流对空腔内噪声有一定抑制效果,使得空腔前部区域声压级降低幅度比后部区域大,射流出口位于腔前壁上(射流方向平行来流)的射流方式对腔内噪声抑制效果要比射流出口位于腔前壁前(射流方向垂直来流)的射流方式好;超声速(Ma=1.5)条件下,采用的零质量射流对空腔内气动声学特性影响很小,对腔内噪声几乎无抑制效果。

关键词: 空腔 零质量射流 气动噪声 抑制方法 声压级 声压频谱

Abstract: Complex unsteady flow characteristics and flow-field structures occur in a high speed flow past open cavities, such as fluctuating pressure and velocity. Some sound pressure level (SPL) inside the cavities can reach 170 dB, which may damage certain installed apparatuses inside the cavity and its structural components. Noise suppression for open cavities is therefore a focus of research. This paper presents an analysis of the aero-acoustic characteristics inside an open cavity of a length-depth ratio (L/D) of 6 with or without a zero-net-mass-flux jet at Mach numbers of 0.9 and 1.5. The suppression effects of different zero-net-mass-flux jets on aerodynamic noise are discussed by analyzing the sound pressure level distribution on the centerline of the cavity floor and the sound pressure frequency spectrum (SPFS) characteristics at different measurement points. The results indicate that the jet can suppress aerodynamic noise inside the cavity, and that, at a Mach number of 0.9, it is more effective in SPL reduction in the front range of the cavity than in the rear. The suppression effect of the jet on the aerodynamic noise within the cavity is better when its exit is on the cavity-fore-face, with its direction parallel to the free-stream, than when its exit is in front of the cavity-fore-face with its direction vertical to the free-stream. The jet has little effect at a Mach number of 1.5.

Keywords: cavity zero-net-mass-flux jet aerodynamic noise suppression method sound pressure level sound pressure frequency spectrum

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