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MEMS矢量水听器封装的流体-结构相互作用

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Fluid-structure interaction of MEMS vector hydrophone in packing processing

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摘要

针对水听器的频响曲线会在透声帽谐振频率处出现共振峰,使水听器频响曲线失真,工作频带变窄等问题。本文考虑水听器的工作环境,通过研究流体-结构相互作用对透声帽谐振频率进行了分析。首先理论分析流体对结构模态频率的影响,分析显示在流体作用下透声帽谐振频率会降低。然后利用LMS Virtual.lab Acoustics有限元软件对空气中和液体中的MEMS矢量水听器芯片和透声帽进行了模态分析;并利用振动平台和驻波管对有否进行透声帽封装的MEMS矢量水听器进行了测试以验证上述分析。验证结果显示:透声帽在水中的实际一阶谐振频率为550 Hz,与仿真结果非常吻合,表明该谐振频率可使水听器工作频带变窄。实验结果表明:对水听器中透声帽的流固耦合模态分析非常必要,通过准确地获得透声帽在实际状态下的固有频率并预测水听器的接收频响特性,可为改进封装结构提供理论依据,为进一步优化水听器奠定基础。

关键词 : 微机电系统(MEMS), MEMS矢量水听器, 流固耦合, 透声帽, 谐振频率, 频带

Abstract :

Some resonant peaks in the frequency response curve of a hydrophone usually appear at the resonant frequencies of the sound-transparent cap, which make the frequency response curve distorted and the working band narrowed. Thereby, it is necessary to forecast the resonant frequencies of the sound-transparent cap accurately. According to the working environment of a MEMS Hydrophone, this paper analyzes the resonant frequencies of the sound-transparent cap based on the Fluid-Structure Interaction(FSI). Firstly, the effect of fluid action on the FSI of the sound-transparent cap was analyzed in theory, and it shows that the resonant frequencies of the sound-transparent cap will be lowered by the fluid action.Then, the vacuum mode and coupling mode of the chip and sound-transparent cap were simulated by LMS V irtual.lab, respectively. Finally, the MEMS vector hydrophones with and without sound-transparent cap packaging were tested in a shaking table and a standing wave tube to verify the above analysis. The results indicate that the actual first-order resonant frequency of sound-transparent cap in water is 550 Hz, which is the same as the simulation and makes the working frequency band of hydrophone narrowed. The results show that the research on coupling modal analysis of sound-transparent cap and predicting the properties of the hydrophone accurately would provide the guarantee for further optimization and improvement of the hydrophones.

Key words : Micro-electro-mechanical System(MEMS) MEMS vector hydrophone fluid-structure interaction sound-transparent cap resonant frequency frequency band

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