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Revised mount structure to reduce the structure-bone noise in bone-conduction earphone

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ABSTRACT

Bone-conduction earphone was used to transfer sound information by exciting the temporal bone in human using uniaxial exciter. Most of bone-conduction device was implemented on a glass structure and sound leakage can be found at attached position due to insufficient anti-vibration mount module supporting the uniaxial exciter. In this paper, negative stiffness concept was used in mount module to minimize the structure-bone leakage sound in glass structure by change the location of uniaxial exciter. The model of bone-conductor was built including the uniaxial exciter and the proper location of mount module as well as the required dynamic stiffness were determined from the simplified model. Test setup regarding the mounted uniaxial exciter was prepared and the performance of proposed mount module was evaluated from the response data, transmissibility and sound pressure.

Keywords: Mount module, Negative stiffness, Leakage sound, Vibration transmissibility, Bone-conduction earphone
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1. INTRODUCTION

Bone-conduction technique[(1)-(2)] was frequently used in a sports industry as one of wearable hearing device to provide sound information to humans indirectly by vibrating temporal bone in human with uniaxial exciter. Wearing person with bone-conduction device can recognize selective sounds from the responsible device, such as music, and it is possible to perceive environmental conditions with ear simultaneously. In addition, the bone-conduction device can help the handicapped persons in hearing parts by vibrating temporal bone in human.

The uniaxial exciter is one of main mechanical component to generate excitation into human bone and conventional products have been developed to implement it on the leg of glass structure. The excitation to the human bone direction should be sufficient enough to carry wanted sound information and the excitation spectrum should be evenly contributed through all frequency range of interest. However, the excitation also contributed on the structural-bone noise in glass structure since the uniaxial exciter transmits same vibration energy into supporting basement as reaction motion. The unexpected structure-bone noise plays critical role at the generation of annoying sound for persons nearby and it may be impossible to use it in quiet place like library. One of countermeasures is to apply sufficient mount module to isolate any vibration from exciter into basement floor[(3)-(4)] and the attached location of uniaxial exciter at the lag of glass is corresponding to the basement floor.

The passive mount module was widely used in mechanical industry because both the installation and maintenance cost are cheap and reliable vibration isolation performance can be obtained by proper design of mount module over the vibration sources. The mount module can be classified into two mechanical components, spring and damper, and mass-block is also used to control the transmissibility in a vibration path[(5)-(9)]. The design requirement of mount module over the vibrating system of interest can be derived from the theoretical model including supporting mount module. The mount module can be modelled with equivalent spring and damper components and the vibration transmissibility can be expected according to the selected value of mount parameters in all frequency range. In application to the bone-conduction device, the location of damper and spring component was based on the location of uniaxial exciter and leaf-type spring and rubber-type connecter were assigned as spring and damper components, respectively. In particular, a positive offset of exciter was applied for the bone-conduction device so that additional stiffness can be derived in the direction of a temporal bone and partial negative stiffness can be expected in an opposite direction. So the leakage sound into the basement floor (or glass leg structure) can be minimized from the revised mount module structure.

The prototype of bone-conduction structure was prepared to conduct the vibration test under applying for the revised mount module design concept and response data, acceleration as radiated sound, was measured under the white noise input at the uniaxial exciter. Pre-pressure was assigned during the measurement process by attaching small mass and its weight force was the same direction of excitation at the mass-centre of exciter. Transmissibility was calculated from accelerations in both excitation position and glass-leg position and leakage sound was calculated at 50cm distance from the bone-conduction device. Experimental result reveals that the transmissibility can be obtained less than 0.2 at all frequency range and leakage sound can be controlled by less than 72(dB).

2. CONCLUSIONS

Revised mount module design concept was suggested by assigning some offset at the uniaxial exciter to provide partially negative stiffness effect at the mount location and efficient location of mount module components, both leaf-type spring and rubber-connecter, was determined using the simplified system model. Experimental result show that the proposed mount module structure was efficient to control the leakage sound at the glass-leg position by the measurement of acceleration transmissibility and radiated sound.

3. ACKNOWLEDGEMENTS

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4. REFERENCES

1. I. Dobrev, J.H. Shim, F. Pfiffner, A.M. Huber, C. Roosli, “Performance evaluation of a novel piezoelectric subcutaneous bone conduction device”, Hearing Research, Vol.370, pp.94-104, 2018.
2. J. Lin, S. Chen, H. Zhang, H. Xiong, Z. Zhang, M. Liang, X. Zhang, H. Ye, Y. Zheng, “Application of implantable hearing aids and bone conduction implant system in patients with bilateral congenital deformation of the external, International Journal of Pediatric Otorhinolaryngology, Vol.119, pp.89-95, 2019
3. S.S. Rao, “*Mechanical Vibration(fifth ed.)”*, Pearson (2011)
4. D.J Inman, *“Engineering Vibration(fourth ed.)”*, Pearson (2013)
5. C.J. Kim, “Design criterion of damper component of passive-type mount module without using base mass-block”, Energies, Vol.11(6), 1548; https://doi.org/10.3390/en11061548, 2018.
6. A. Siami, H.R. Karimi, A. Cigada, E. Zappa, E. Sabbioni, “Parameter optimization of an inerter-based isolator for passive vibration control of Michelangelo’s Rondanini Pieta”, Mechanical Systems and Signal Processing, Vol.98, pp.667-683, 2018
7. Z. Wu, X. Jing, B. Sun, F. Li, “A 6DOF passive vibration isolator using X-shape supporting structures”, Journal of Sound and Vibration, Vol.380, pp.90-111, 2016
8. J. Lee, C.E. Okwudire, “Reduction of vibrations of passively-isolated ultra-precision manufacturing machines using mode coupling”, Precision Engineering, Vol.43, pp.164-177, 2016
9. E.A. Ribeiro, E.M.O. Lopes, C.A. Bavastri, “A numerical and experimental study on optimal design of multi-DOF viscoelastic supports for passive vibration control in rotating machinery, Journal of Sound and Vibration, Vol.411, pp.346-361, 2017