Mechanical model and vibration reduction analysis of a Z-type energy harvester

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Abstract

this paper investigates the dynamic modeling and optimization of a V-type energy harvester. The research of energy harvester pays more and more attention to practicality. Therefore, an new energy harvester is designed, which can be placed under the soles of people's shoes. Firstly, the model of V-type energy harvester is designed, and the mechanical model is established to analysis the natural frequency. Two V-type energy harvesters are combined into one Z-type energy harvester. Secondly, the finite element analysis of V-type and Z-type energy harvesters are carried out, and the displacement, stress, strain are pointed out. Furthermore, the natural frequency is compared with the theoretical value, and the maximum strain position is pointed out. The results show that the modeling method and analysis results are correct.

1 Introduction

A new V-type energy harvester is designed, modeled and analyzed, and the natural frequency can be obtained by theoretical analysis. Moreover, two V-type energy harvesters are combined into one Z-type energy harvester. The natural frequency, static displacement, stress and strain of the two types energy collectors are calculated by finite element software, and the position of the maximum strain is pointed out in order to paste energy collection devices.

2 Geometric model and mechanical model

2.1 Geometric model

Considering the situation of human walking, the movement of feet is continuous. A V-type energy harvester is designed and installed at the bottom of shoes. The model the V-type energy harvester is shown in the Fig.1, and the parameters of the structure are shown in the Tab. 1. When the included angle θ between the two parts determined by the energy harvester is different, the deformation is also different. Moreover, if two V-type energy harvesters are combined into one Z-type energy harvester, its surface is more straight and convenient for installation. Sensor such as MFC patch or PVDF film is pasted at the root of the structure, and there is lattice material at the bottom for vibration reduction.

Table 1 model parameters

type	V-type energy harvester					Double V, Z-type				
parameter	L_1	D_1	θ_1	l_1	h	L_2	D_2	θ_2	H	l_2
value	45mm	25mm	25 °	45mm	2.5mm	45mm	25mm	25 °	25mm	52.5mm
Physical parameters	$\boldsymbol{E}$=210GPa, $\boldsymbol{\rho}$=7800kg/m^3, $\boldsymbol{S}=D_i h$, $\boldsymbol{m_\theta=\rho S l_1}$									

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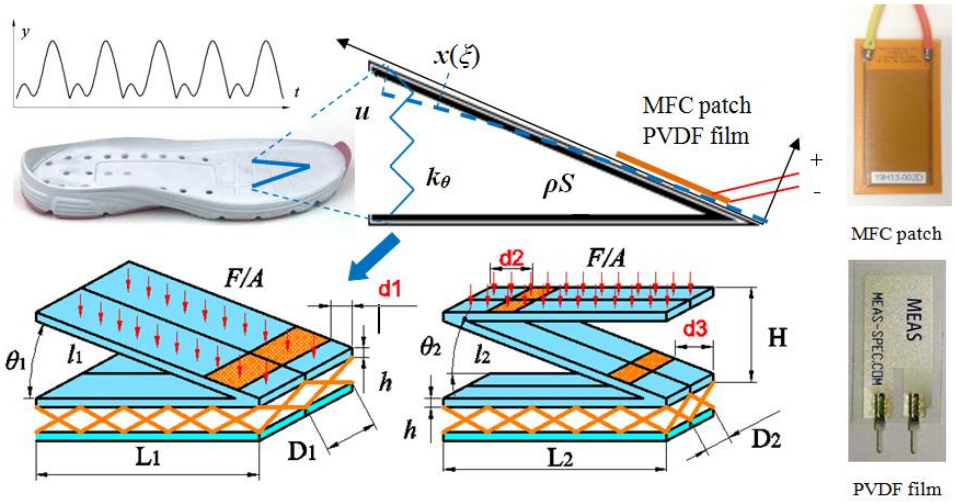

Figure 1: Geometric model

3 Simulation analysis

When the structural parameters are determined, the deformation is calculated corresponding to the determined included angle. ABAQUS software is used to analyze the displacement, stress, strain and frequency. When two V-type structures are placed on the sole, each structure bears half of the adult weight of 70kg. The positions of the maximum displacement, stress strain are pointed out. Moreover, the natural frequency can also be calculated for comparison. Combined with theoretical analysis, the stiffness coefficient k_θ is obtained by calculation. However, the natural frequency calculated by finite element method may not be equal to the theoretical value. Therefore, the stiffness coefficient needs to be corrected.

4 Conclusion

In this paper, a new type of V-shaped energy harvester is designed, modeled and analyzed, and two V-shaped structures are combined into a Z-shaped energy harvester. The position of the maximum strain is near the corner of the structure, and the MFC patches can be placed here as energy harvesters. Therefore, it is concluded that this energy harvester can be well applied to footstep energy acquisition.

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