Vibration and Noise Reduction Mechanism with Leaf Spring Module for Treadmill

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Abstract

In recent times, there has been an increasing demand for indoor fitness equipment owing to growing health concerns. However, most types of commercial fitness equipment produce the vibration and noise, which may be a disturbance not only to the user but also to others in the immediate vicinity. Therefore, we propose a vibration and noise reduction module that can be used such equipment. This module has six silicone springs placed on the support frame of the equipment. In this paper, we describe the design, analysis, and experimental results of the proposed module. The proposed reduces vibration by more than 15% as compared to conventional module.

1 Introduction

Indoor fitness equipment such as a treadmill, stepper, and bicycle produce vibration and noise, which may be a disturbance to people in the immediate vicinity, especially if one lives in an apartment building. In this study, we propose a novel module for reducing this vibration and noise.

1.1 Concept design and analysis

The device with coil spring and fluid damper is widely used to reduce vibration of the fitness equipments. However, the manufacturing cost of such a device is quite high. Therefore, in order to reduce the cost, we proposed the use of silicone springs. In a conventional vibration-reduction arrangement, a treadmill pad is fixed onto a housing

using four set of nuts and bolts. This arrangement is shown in Figure 1; the sets of nuts and bolts are denoted by dashed arrows are unfastened; the compliance between the treadmill mechanism and the housing mechanism in the resultant arrangement will be higher than that in the conventional arrangement. Such a high compliance may result in less vibration. As the silicone springs are sufficient for supporting the pad, only the two sets of nuts and bolts denoted by solid arrows are used in our module.

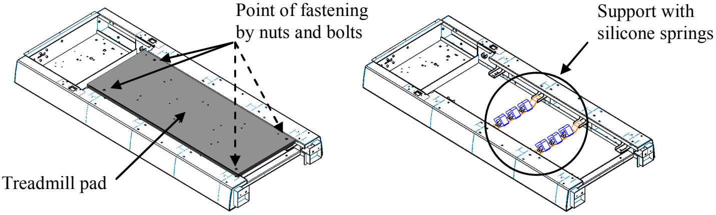

Figure 1 Installation of treadmill pad and silicone springs

Figure 2 shows a photograph of a silicone spring. The asymmetric hexagonal shape of this spring reduces the stress concentration caused by a vertical load. The reduced stress concentration results in a greater durability of the spring. The performance of the proposed spring was simulated by conducting a finite element analysis using commercial simulation software (ANSYS™). The maximum stress on the spring was observed to be 3.50 MPa, as shown in Figure 3.

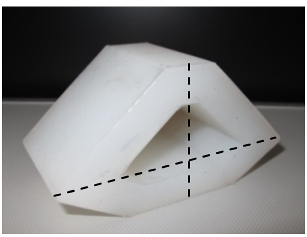

Figure 2 Fabricated silicone spring

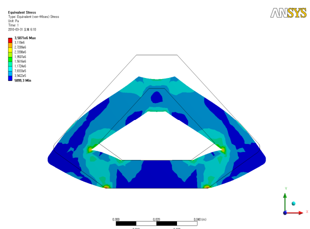

Figure 3 Distribution of stress

The force transmissibility of the spring is calculated using Eq. (1), where F_t is the force transmitted through the spring and damper; and F_0, the force applied by the user of the treadmill; T_y, the transmission ratio; ω, the excitation caused by the user;

and ω_n, the natural frequency of the treadmill. The required parameter, stiffness k, is calculated from ω_n. The calculated value, k, is compared with the combined spring constant of the mechanism with the pad, housing and spring and the mechanism design is adjusted iteratively. [1]

$$T_r = \frac{F_t}{F_0} = \left[\left\{ 1 + \left(2\xi \frac{\omega}{\omega_n} \right)^2 \right\} \Big/ \left\{ \left[1 - \left(\frac{\omega}{\omega_n} \right)^2 \right]^2 + \left(2\zeta \frac{\omega}{\omega_n} \right)^2 \right\} \right]^{1/2} \tag{1}$$

2 Experiment

2.1 Experimental setup

The purpose of the experiment is to investigate the vibration reduction brought about by the silicone spring model. The vibration of the treadmill is calculated on the basis of the acceleration on the floor measured using an accelerometer. The measured data is transmitted to a personal computer via a wireless communication device, ANYLOGGER™. Software programs for data acquisition and a signal analysis are installed on the computer. Figure 4 shows the experimental set-up (left) and a photograph of the arrangement of the silicone spring, pad, and housing (right).

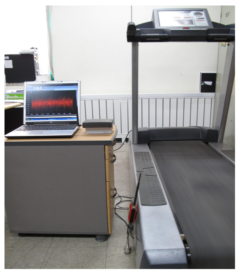

Figure 4 Experimental set-up

2.2 Experimental results

The vibration in the proposed module is estimated by comparing it with that in a conventional treadmill. All experiments are carried out on the same treadmill. The acceleration in the conventional and proposed module is 4.16 m/s^2 and 3.35 m/s^2, respectively. In other words, vibration in the proposed module is reduced by more than 15%, as shown in Figure 5.

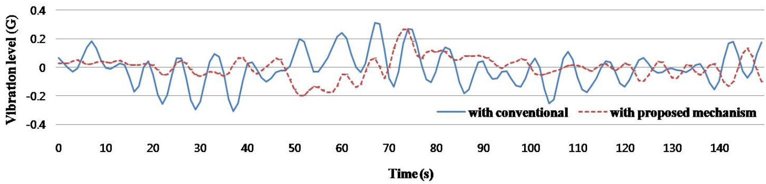

Figure 5 Measured acceleration of the user

3 Conclusion

In this paper, we have described the design, analysis, fabrication, and experimental results of a mechanism for reducing the vibration and noise caused by indoor fitness equipment. The performance of the proposed module is analyzed by measuring the acceleration on the floor; this performance is shown in Figure 5. The proposed silicone spring module is advantageous because it decreases the vibration transferred to below the treadmill and the manufacturing cost of this module is low. Further, the proposed treadmill vibration-reduction module has a simpler structure and is more durable than other vibration-reduction module. Therefore, the mechanism of our proposed module can be applied to other indoor fitness equipment. Furthermore, this mechanism can be applied to high precision machines. By reducing the vibration in a module that involves a repetitive process, the accuracy and repeatability of the module can be enhanced.

Acknowledgement

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