A NOVEL 3-D HAND-ARM VIBRATION TEST SYSTEM AND ITS PRELIMINARY EVALUATIONS

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Introduction

Vibration exposure at workplaces is generally multi-axial. The health effects of vibration exposure also likely depend on the vibration direction. Therefore, there is a wide interest in the simulation of multi-axial vibration in laboratory experiments. Advances in technology have led to the development of a new 3-D test system for studying hand-transmitted vibration exposure and health effects. The purposes of this paper are to introduce the system and to present the results of its preliminary evaluations.

Test System

As shown in Figure 1, the system is basically composed of three vibration generators, a multi-axis vibration control system, instrumented handle, handle fixture, and shaker-fixture linkages (stingers).

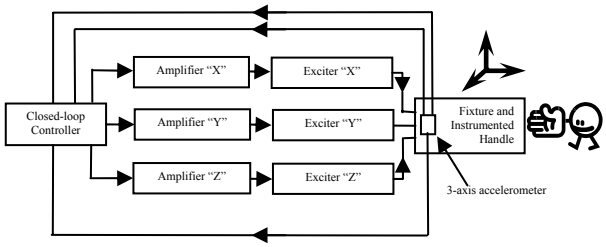


Figure 1: System block diagram

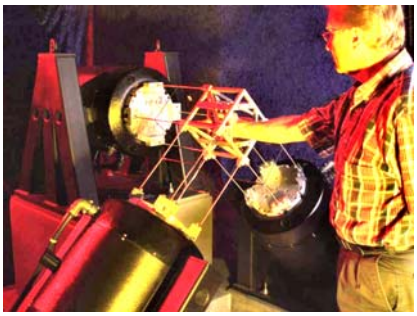


Figure 2: Configuration of the 3-D system

Figure 2 shows the array of three vibration generators (MB Dynamics, Energizer BLACK-500 lbs) and their associated support bases and foundation developed by MB Dynamics (Cleveland, USA), which create the 3-axis simultaneous motion. These electrodynamic exciters are powered by power amplifiers which provide current proportional to the analog drive signal from a controller. The controller (JAGUAR Multi-Input/Multi-Output closed-loop vibration controller) was provided by Spectral Dynamics, San Jose, California, USA). NIOSH-designed instrumented handle was equipped on the system.

System Evaluation Methods

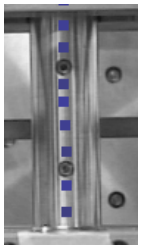


Figure 3: Vibration Distribution measurement

Several preliminary experiments have been performed to examine the characteristics of the system and its performance. A laser vibrometer (Polytec PI, H-300) was used to examine the distribution of sinusoidal acceleration on the handle vibrating at 2g in three directions, as shown in Figure 3a. The system was used to simulate 3-D sinusoidal vibration, a broadband random vibration from 7.5 Hz to 500 Hz, and a cutting saw vibration spectrum.

Evaluation Results

Figure 4 shows the distribution of the vibration on the handle. The maximum difference of the distribution along the handle longitudinal direction in the frequency range (<500 Hz) of concern was less than 9%.

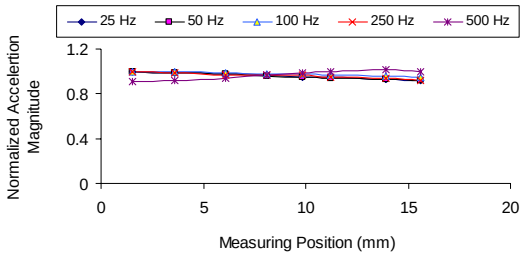
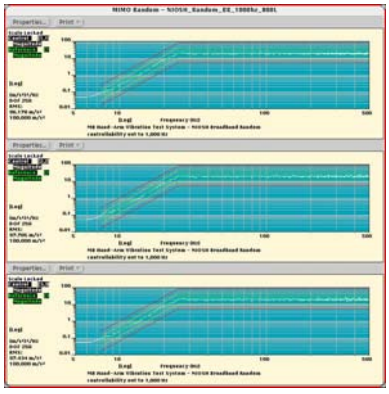
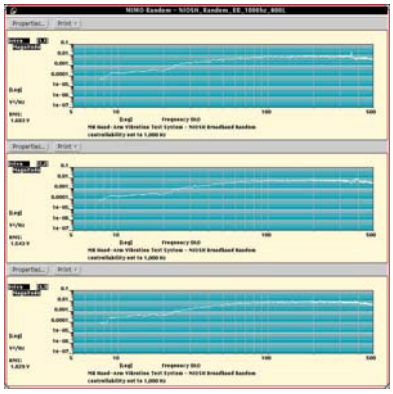


Figure 4: Vibration distribution on the handle

As an example, Figure 5 (a) and (b) display the Control and Drive plots demonstrating full performance. Overall noise levels due to the 10 g's RMS vibration on each axis exceeded 96 dBA in a 52 dBA ambient environment absent the vibration.



(a) Control signal



(b) Drive signal

Figure 5: System performance

Conclusion

These preliminary results suggest that it is acceptable to use the 3-D test system to simulate the sinusoidal, broadband random, and time-history vibrations.