ASSESSMENTS AND REFINEMENTS OF AN ANTHROPODYNAMIC MANIKIN FOR SEATING DYNAMICS APPLICATIONS

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Introduction

The current laboratory methods for assessing the vibration attenuation performance of seats involve repetitive trials with a number of human occupants, and raise certain ethical concerns. Moreover, the measurements with human subjects yield considerable variability in the data. Alternatively, several anthropodynamic manikins have been developed for effective assessments of the coupled seat occupant system [1]. The effectiveness of a manikin in predicting the response of a coupled seat-occupant system lies in its ability to reproduce the biodynamic response of the seated human body in terms of force-motion relationship at the body-seat interface, such as apparent mass (APMS). A number of prototype manikins have thus been developed on the basis of biodynamic characteristics of vertical vibration-exposed seated occupants of different body masses in the vicinity of 5th, 50th and 95th percentile male population. This study concerns with the analysis of a passive prototype manikin to enhance its ability to reproduce the idealized APMS response characteristics of the vibration-exposed seated human subjects defined in ISO-5982[2] for mean body masses of 55, 75 and 98 kg.

Methods

The APMS responses of a prototype anthropodynamic passive manikin were thoroughly characterized in the laboratory under different excitations and body mass configurations. The manikin was designed with sufficient flexibility to configure mechanical-equivalent models corresponding to seated body masses of 55, 75 and 98 kg, by adding/removing specified masses and springs (Fig. 1). The manikin, configured for a specific body mass, was positioned on a rigid seat without a backrest, which was fixed to the force platform of a whole-body vertical vibration simulator. The simulator was programmed to synthesize random vertical vibration with flat acceleration power spectrum in the 0.4-20 Hz frequency range with two different magnitudes: 1 and 2 m/s^2 overall *rms* acceleration. The total static and dynamic forces of the manikin to and the seat were measured using the force platform, while a single axis accelerometer was installed on the seat pan to measure acceleration due to vertical excitation. The measured data was appropriately corrected for the rigid seat inertia force, and the apparent mass

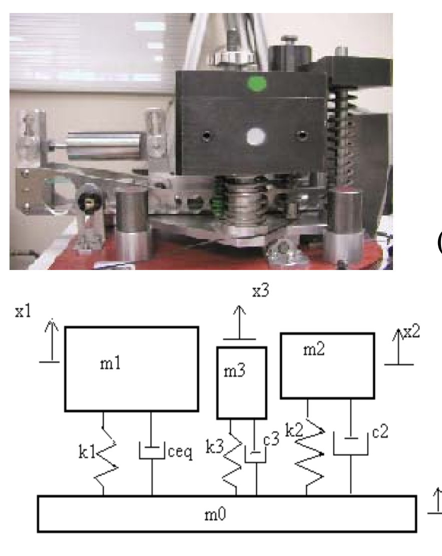

Fig. 1: A pictorial view and mathematical model of the manikin

characteristics of the manikin were derived using the 50 Hz bandwidth and the frequency resolution of 0.0625 Hz. A mathematical model of the manikin was also developed upon considerations of the components properties, and the motions due to various linkages. A linear three-DOF model was formulated to compute the APMS responses for different mass configurations (Fig. 1). A constrained optimization-based parameter identification method was applied for identifying desired components properties such that the manikin could accurately reproduce the idealized APMS responses of the seated human occupants for the three body masses.

Results and Discussions

Figure 2(a) illustrates the measured APMS magnitude responses of the manikin for three mass configurations under 2 m/s^2 excitation. The magnitude peaks occur near 4, 4.8 and 4.5 Hz respectively for the 55, 75 and 98 kg masses. Comparisons of the measured data with the standardized responses in ISO-5982 [2] revealed that the APMS responses of the manikin for 55 and 75 kg masses lie within the lower and upper bounds of the idealized range defined in the standard. For the 98 kg configuration, the measured magnitude exceeded the upper bound near the primary resonant frequency. Moreover, the primary resonant frequencies corresponding to 75 and 98 kg configurations deviated considerably from those of the idealized values. The manikin also provided extremely poor prediction of the APMS responses under lower excitation levels, which was attributed to relatively high damper seal friction. The results attained from the optimization based parameter identifications suggested that the response predictions of the manikin could be considerably enhanced through only minor refinements of the component properties. As an example, Fig. 2(b) shows comparisons of the measured and idealized responses for the 75 kg mass with that of the refined design.

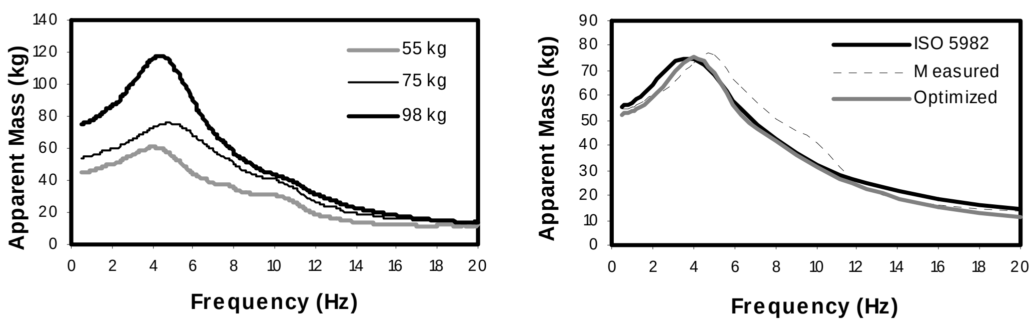

Fig. 2: (a) Measured APMS responses of the manikin; (b) comparisons of measured and standardized responses with that of the refined design (75 kg).

References

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[2] International Standard 5982, 2001 "Mechanical Vibration and Shock-range of idealized values to characterize seated-body biodynamic response under vertical vibration".