A STUDY ON MODELING OF HUMAN BODY EXPOSED TO VEHICLE VIBRATIONS

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Abstract: Vibration is one of the important considerations in design of light motor vehicles. It becomes most important to study the vehicle vibrations for human body comfort. The model fabrication is done on the basis of comparing real human body parameters with human physical models used in the ISO 10068:2012 standard. This article revealed effect of vibration transferring to the specific parts of human body due to vibration transferring from Seat to Height (STH) and from Hands on steering. The focus of the present study was to determine the vibration output from fabricated model. The vibrations as input to the model are from automotive vehicles. The input verses output vibration characteristics will be useful to study effects of vibration on human health. The human body is considered as a simple spring, mass, damper system for analysis. This multi body model representative of the automotive postures found in the literature were investigated, one with and the other without a backrest support. The model was modified to suitably represent the different automotive postures with and without backrest supports, to the same postural conditions on the basis of the analytical study. The prepared model has been further compared with similar model provided in the literature on automotive sitting environments.

Key Words : **Vehicle vibrations, energy flow, human body comfort, hand-arm vibrations, hands on steering, Seat to height vibrations**

1. INTRODUCTION

Mechanical vibrations generated by vibrating systems of power tools or transport vehicles can have a negative impact on the human body. Long-term exposure to vibrations can cause many disorders in the operator's body, leading to permanent damage. In a seated position, humans are most sensitive to full body vibrations under less frequency excitation; hence, biodynamic responses of a seated human body when exposed to vertical vibrations have receive much attention through the years. Moreover, it is important to understand the cause-effect relationships in between the vibrations transmission through the body, its health, comfort and performance. These responses have been widely assessed in terms of seat-to-head (STH) transmissibility, driving point mechanical (DPM) impedance, and apparent (AP) mass [1]. The first function refers to the motion transmission thorough the body; whereas the other two refers to the force and motion at the point of vibration input. The human body is dynamic system whose mechanical properties changes from moment to moment and from person to person. From the results of a large amount of experimental data, various mathematical models have been developed to describe human motion. According to different techniques, these models can be grouped as lumped-parameter (LP), finite element (FE), and multibody (MB) models [2].

2. MODELLING OF HUMAN BODY

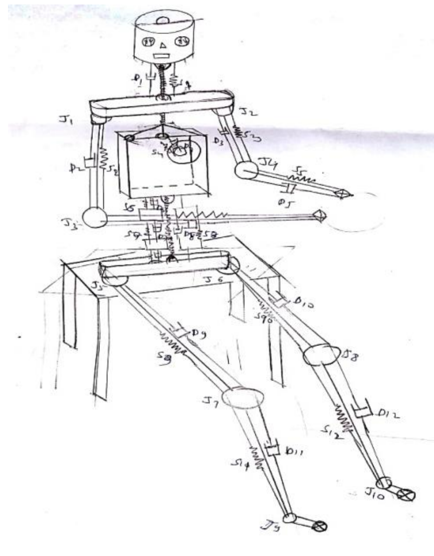

Figure 1 Proposed system layout

MB model of consist of several rigid bodies interconnected by bushing elements (rotational and translational spring-damper units), pin (2-D) and/or ball-and-socket (3D) joints. The 3-D model is designed and fabricated by comparing specifications. Then used in the study of biodynamic responses of the human body. For the responses of a seated body exposed to vertical vibrations, mathematical models was at least 2-D in the sagittal plane. Especially in an automotive seating environment, bouncing and pitching motions are the important factors in vehicle riding assessment. As a result (shown in fig number 1), a few 2-D models reaches minimal satisfaction of the mentioned body.

3. MEASUREMENTS AND MATHEMATICAL MODEL

As mentioned earlier, from a few years several mathematical models for the study of biodynamic responses of a sitting body are printed on the idea of individual take a look at knowledge. As part of this study, the basic assumptions and experimental data for the analysis of seated humans exposed to vertical vibrations will be studied first. Moreover, MB model, having fourteen degrees of freedom (DOFs) will be illustrated and summarized in this section of study [4].

3.1Measurements without Backrest Support

A variety of test data used to categorized the biodynamic response functions has been established by using different variety of testing conditions, most of which can be grouped in the data sets for a seated body without back rest support. Such grouping has resulted in considerable discrepancies among the data. To avoid these deficiencies, a primary conclusion was reached that any attempt to define generalized values might not be correct unless it could be defined specifically for a particular application or within a limited but well-defined range of situations. From the literature, data sets satisfying the following requirements were selected for the study of biodynamic characteristics of seated human subjects [5].
Body masses were limited to the range within 49–94 kg;
The feet were supported and vibrated;
Data sets tested under vibration excitations were exposed to the vertical direction;
Vibration excitation amplitudes were below 5 m/s2, the nature of excitation being specified as either sinusoidal or random;
The excitation frequency range was limited to 0.5–20 Hz.

3.2 Measurements with Backrest Inclined 21°

In this study only the STH transmissibility data were selected to validate the targeted MB models to avoid comparisons of the response function from simulations, and data is compared with data of Experimental results: seated human body exposed to vertical vibrations without backrest support from Cho-Chung LIANG1 and Chi-Feng CHIANG1.

3.3 Measurements with Backrest Inclined 12°

Because of associate in nursing, incomplete information of the mechanical properties of the body, the effect of hand positions and body mass on AP mass is difficult to determine. This research studies only on the effect of the backrest angle on the biodynamic response functions. The AP mass values measured at three different back-support positions, representing a flat pan with the back unsupported, and with the back supported by a vertical backrest or an inclined backrest as mentioned in Cho-Chung LIANG1 and Chi-Feng CHIANG1.

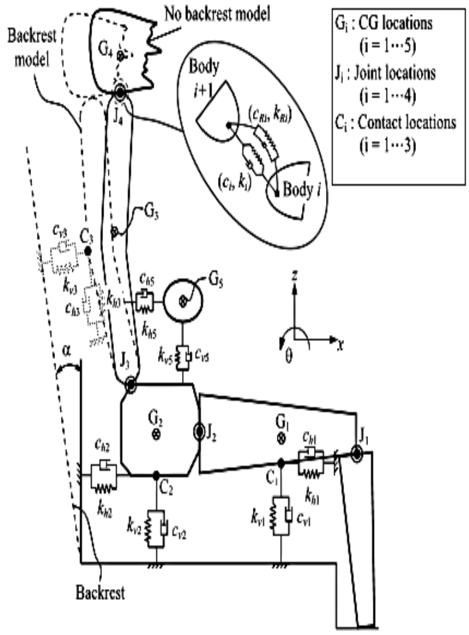

Figure *2* Cho Chung Liang and Chi Feng Chiang Model

As previously mentioned, the experimental studies on the biodynamic of a seated human body exposed to vertical vibrations have been widely assessed in terms of STH transmissibility, DPM impedance, and AP mass. Moreover, the support in automotive seating environments contributes to decrease muscle tensions and maintain sitting posture throughout driving.

Derivations of system

$$Ceq=\frac{C1*Cs1}{C1+Cs1}\ ;\ Keq=\frac{(C12ks1+CS12k1)+K1KS1(C1+CS1)}{(K1+KS1)+S(C1+CS1)}\ ;$$

$$[M]\cdot\{\ddot{q}\}+[C]\cdot\{\dot{q}\}+[K]\cdot\{q\}=\{f_E\}$$

Where [M], [C], and [K] are the 14 × 14 mass, damping and stiffness matrices, respectively; {q} is the vector of generalized coordinates; $\{f_E\}$ is the force vector due to external excitation.

By considering model as a simple spring mass system with certain assumptions derivations for following measurements were derived.

(a) Measurements without backrest support
(b) Measurements with backrest inclined 21°
(c) Measurements with backrest inclined 12°

4. CONCLUSION

A study of MB models of a fixed human body on a platform which is exposed to vertical vibrations has been implemented. The model proposed in this study has been analyzed in terms of STH transmissibility.
From the analysis following comments can be made:

For responses of a seated body exposed to vertical vibrations, the models must be at least 2-D in the sagittal plane. Therefore, the MB model in this study was observed when sitting both with and without backrest supports, irrespective of hand positions, while the feet were supported and allowed to vibrate. In the biodynamic analyses both models were simplified to linear systems to reduce the analytical and simulation complexities.

The proposed model is fit in different automotive sitting environments very well. It is recommended that the proposed model be used in evaluations of the biodynamic responses of a seated human body exposed to vertical vibrations in various automotive postures.

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