International Journal of Industrial Ergonomics 41 (2011) 418–427

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

The vibration transmissibility and driving-point biodynamic response of the hand exposed to vibration normal to the palm

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ARTICLE INFO

Article history:
Received 20 August 2009
Received in revised form
3 May 2011
Accepted 27 May 2011
Available online 28 June 2011

Keywords:
Hand-arm vibration
Hand-transmitted vibration
Driving-point biodynamic response
Hand vibration transmissibility
Palm sander
Orbital sander

ABSTRACT

Prolonged, intensive exposure to vibrations from palm and orbital sanders could cause finger disorders. They are likely to be associated with the biodynamic responses of the fingers. Although the biodynamic responses of the hand-arm system have been studied by many researchers, the detailed biodynamic responses distributed in the hand substructures have not been sufficiently understood. To advance the knowledge in this aspect and to aid in the development of improved finite element models of the substructures, this study simultaneously measured the overall driving-point biodynamic response and the distribution of vibration transmissibility at the fingers and back of the hand exposed to a flat plate vibration (as an approximate simulation of the operations of the palm and orbital sanders) and examined the relationship between these two measures of biodynamic responses. Ten subjects (five males and five females) participated in the experiment. A scanning laser vibrometer was used to measure the distributed vibration. This study confirmed that the distributed hand responses generally varied with locations on each finger, vibration frequencies, and applied hand force. Two major resonances were observed in the vibration transmissibility. At the first resonance, the transmitted vibrations at different locations were more or less in phase; hence, this resonance was also observed in the driving-point biodynamic response that measures the overall biodynamic response of the system. The second resonance was observed at the fingers. Because this resonant frequency varied greatly among the fingers and the specific segments of each finger, it is difficult to identify this resonance in the driving-point biodynamic response. The implications of the findings for further model developments and applications are discussed.

Relevance to industry: This study enhanced the understanding of the biodynamic responses of the fingers and hand exposed to vibrations on a contact surface with a large effective radius such as that found on palm and orbital sanders. The results can also be used to develop and/or validate models of the substructures of the hand-arm system, which can be further used to help design and analyze these tools and associated anti-vibration devices. The results may also be applicable to help develop location-specific frequency weightings to assess the risks of the finger vibration exposure.

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1. Introduction

Palm sanders and orbital sanders are widely used in the furniture manufacturing. Such tools usually generate fairly high-frequency vibrations (Griffin, 1997), which are largely absorbed by the hand, especially the fingers (Dong et al., 2005c; Dong et al., 2008a). Prolonged, intensive exposure to such vibrations could cause symptoms of hand-arm vibration syndrome such as vibration-induced white finger. The risk assessment of the syndrome is currently based on International Standard ISO 5349-1, 2001. Although vibration-induced white finger is a unique and important component of the hand-arm vibration syndrome, epidemiological studies have not shown reasonable agreement between the observed risk of vibration-induced white finger and that predicted by the ISO-5349 model (Lidström, 1977; Bovenzi et al., 1980; Bovenzi, 1998; Griffin, 1997, 2008; Griffin et al., 2003). One of the possible reasons is that the current ISO frequency weighting may be inappropriate for the assessment of vibration-induced white finger. An effective approach to develop an improved frequency weighting for such an assessment is to study

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0169-8141/$ – see front matter Published by Elsevier B.V.
doi:10.1016/j.ergon.2011.05.007