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RESONANCES OF THE HUMAN HAND-ARM SYSTEM USING FINITE ELEMENT AND OPERATIONAL MODAL ANALYSIS METHODS

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ABSTRACT

Resonance frequencies of the human hand-arm system in the extended and bent-arm postures were derived from finite element (FE) models of the hand-arm system, and operational modal analysis of the measured acceleration signals using autoregressive moving average technique. Modal, harmonic and Von-Mises strain analyses of the FE models were also performed to derive strain-based frequency weighting for the palm (hand), wrist, elbow and shoulder. The results showed that important resonant frequencies in the zh-axis for the extended arm posture are in the following ranges: 10.9 -15, 27.7 – 39.9, 87.9 – 99.2 and 97.8 – 110.0 Hz. The resonance frequency ranges for the bent-arm posture are: 13.0 – 17.3, 27.2 – 36.8, 53.4 – 62.0, 78.1 – 89.9, 152.3 – 154.0 and 164.0 – 169.9 Hz. The results further showed that the hand-arm is subjected to repeated extension and compression along the z_h-axis in the 10.9 – 17.3 Hz frequency range, which is close to the frequency of maximum weight (12.5 Hz) in the frequency weighting recommended in the International Standard Organization ISO 5349-1, Mechanical vibration and shock– Measurement and evaluation of human exposure to mechanical vibration – part 1: General requirements, 2001. This suggests that the hand-arm may suffer injury of the joints (wrist, elbow and shoulder) in the 10.9 – 17.3 Hz frequency range. The results of the strain analysis showed that high strain is developed around the elbow and shoulder below 30 Hz for both postures, while the strain developed in the palm is constant in the 2 – 200 Hz range and higher than strains developed in the wrist, elbow and shoulder above 30 Hz. The strain-based frequency weightings obtained from FE models are comparable with some of the frequency weightings reported in the literature.

Keywords: *Hand-arm Models, Finite Element, Hand-transmitted Vibrations, Frequency Weightings, Strain Distribution.*