TIME-FREQUENCY ANALYSIS OF HAND-TRANSMITTED VIBRATION OF IMPACT TOOLS USING ANALYTIC WAVELET TRANSFORM

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Introduction

Prolonged, extensive exposure to hand-transmitted vibration could cause a series of vibration-induced disorders in the vascular, sensorineural, and musculoskeletal structures of the human hand-arm system, which have been collectively called hand-arm vibration syndrome (HAVS).[1] To assess the risk of HAVS the international standard ISO 5349-1 (2001)[1] recommends using the root-mean-square (rms) acceleration of the measured vibration with a frequency weighting. While a few epidemiological studies have reported results consistent with the predictions made according to the recommendation, many other studies have reported results with large discrepancies.[2] This may be partially attributed to the time-averaging effect involved in calculation of the frequency components, especially for impact type tools. Because the spectral characteristics of impact tools change dramatically with time, a time-frequency (T-F) analysis can provide better characterizations of such highly transient vibrations. The analytic wavelet transform (AWT) is an ideal T-F analysis tool because it possesses the advantages of both the Fourier transform and the wavelet transform.[3] The objective of this study was to explore the application of the AWT method for characterizing the impact tool vibrations and assessing their exposure risk.

Methods

Five tools (two chipping hammers, two riveting hammers, and one concrete cutting saw) were used in this study. The saw vibration was measured when it was used to cut a section of road pavement during a repair. The vibrations on the other tools were measured by the procedure specified in ISO 8662-2 (1992).[4] A sampling rate of 16,386 Hz was used in the measurement. The AWT and Fourier analysis were applied to these signals and to identify their characteristics.

Results

Figure 1 compares the T-F characteristics of the accelerations measured from the relatively steady concrete saw and a riveting hammer. The frequency weighting specified in ISO 5349-1[1] was applied in the calculations. The comparison clearly shows that the two tools have completely different T-F characteristics.

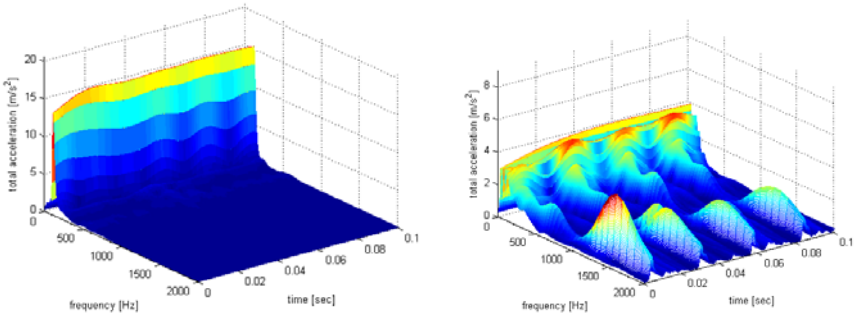

Figure 1: T-F characteristics of a concrete saw (left) and a riveting hammer (right).

Figure 2 compares the frequency-weighted and un-weighted 1/3 octave band spectra of the tools used in Figure 1. The spectra, especially in weighted forms, are not as strikingly different as those in Figure 1.

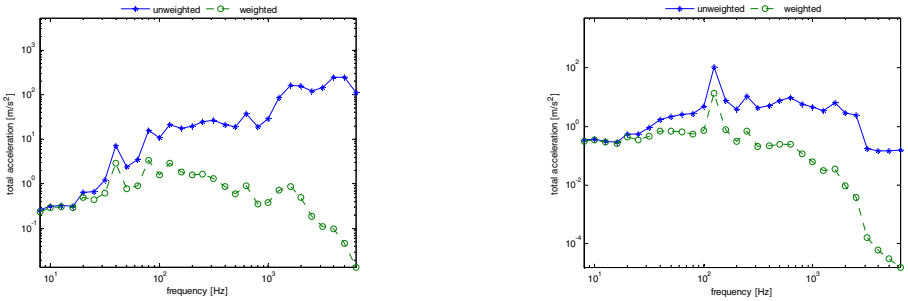

Figure 2: 1/3 octave band spectra of a concrete saw (left) and a riveting hammer (right).

Discussion

The frequency-weighted spectrum such as shown in Fig. 2 is used as the basis to calculate the vibration exposure dose in the standardized method.[1] The time averaging effect evens out the effect of sharp peaks that can be observed in Fig. 1. The health effects or thresholds of vibration exposure may be non-linear with respect to vibration magnitude, which may not be fully taken into account by the standard time-averaging- based method. The time-frequency-weighted acceleration can be calculated from the T-F spectra shown in Figure 1. Because the temporal changes of the frequency components can also be taken into account, the T-F method is believed to be a better approach than the conventional method for assessing the risk of impact vibration exposure.

References

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4. ISO 8662-2, 1992: Hand-held portable power tools - Measurement of vibrations at the handle - part 2: Chipping hammer and riveting hammers. Geneva, Switzerland: International Organization for Standardization.