MODELING OF HAND-ARM VIBRATION

Akul Joshi, Robert Guttenberg, Ming C. Leu
Department of Mechanical and Aerospace Engineering
University of Missouri-Rolla, U.S.A.

Susan L. Murray
Department of Engineering Management and Systems Engineering
University of Missouri-Rolla, U.S.A.

Introduction

The aerospace and automotive industries are facing a significant risk for cumulative trauma disorders from high-repetition, long-duration tasks. Additional risk factors such as shocks, vibrations and sustained uncomfortable postures oftentimes contribute to musculoskeletal, neurological injuries associated with the hand-arm system. The power tools used for the operation reduce the comfort and working efficiency of the operators, thus lowering their health and safety and the quality of operation. This paper investigates the fastening operation on the assembly line of a major aerospace company for quantifying hand-arm vibrations with the objective of developing a dynamic model of the hand-arm system. The model will be used to ascertain the effect of the various risk factors on the quality of the operation.

Experiment Setup

A system of three tri-axial accelerometers is used to collect vibrations entering the hand-arm system and their positioning follows the ISO-5349 standard. Reaction force during the operation is measured using a force sensor. The posture of the hand-arm system is measured using two goniometers and one torsiometer. The pilot study conducted has two subjects and one pistol-grip power tool. The experiment setup and positions of various sensors is depicted in Figure 1.

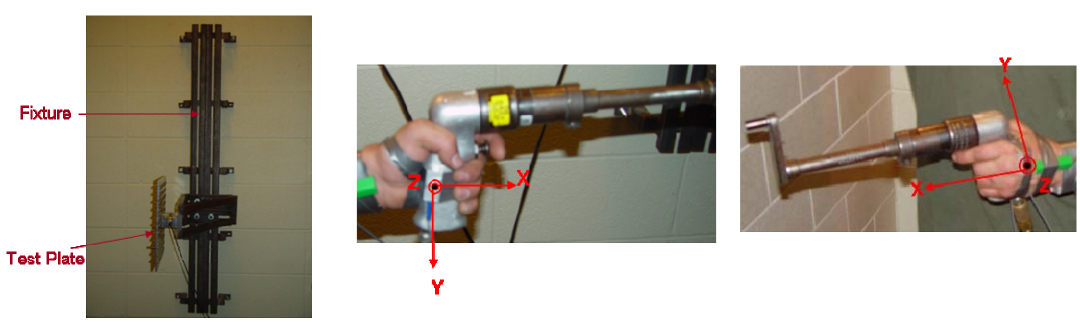

Figure 1: Experiment setup and position of various sensors

Analysis Method

The analysis consists of transmissibility of vibrations and frequency weighted acceleration based on the recommendations of the ISO-5349 standard [1,2]. The transmissibility [3] was deduced in frequency domain after measuring data in time domain from the accelerometers mounted on the tool and third meta-carpel of the primary hand of the operator. The ISO frequency weighting function was utilized to calculate the frequency weighted r.m.s values of acceleration for the power tool to get the probability of finger blanching. The transmissibility is calculated as follows:

$$\text{Transmissibility} = T = \frac{A_h(\omega)}{A_t(\omega)} = \frac{\sqrt{A_{hx}^2(\omega) + A_{hy}^2(\omega) + A_{hz}^2(\omega)}}{\sqrt{A_{tx}^2(\omega) + A_{ty}^2(\omega) + A_{tz}^2(\omega)}}$$

Where $A_h(\omega)$ and $A_t(\omega)$ are frequency weighted r.m.s accelerations measured by the hand and tool accelerometers, respectively. The frequency weighted 8-hour equivalent r.m.s acceleration is given by:

$$A(8) = a_{fwrms}\sqrt{\frac{t}{t_0}}$$

Where a_{fwrms} - the frequency is weighted r.m.s acceleration and *t* is the operation time.

Conclusion and Future Work

The transmissibility was found to be consistent for all trials for a subject. The frequency range for (T >= 1) is approximately 5-200 Hz and the lower bound of the frequency range for (T <= 0.1) is about 300 Hz. The average number of years taken to induce 10% probability of finger blanching was found to be about 20 years for the subjects and tool studied.

The transmissibility analysis will be used for deriving the dynamic model of the hand-arm system. The model generated would be used to determine the energy input to the hand-arm system for various postures and tools. Computer simulation software to assist the designer in evaluating operator ergonomics and manufacturability during the design phase for future tools/fixtures will be developed based on this study.

Acknowledgement

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References

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3. Reynolds, D. D., Angevine, E. N., 1977, Hand-arm vibration. Part II: vibration transmission characteristics of the hand and arm, Journal of Sound and Vibration, 51(2), 255-265.