VIBRATION CHARACTERISTICS OF GOLF CLUB HEADS IN THEIR HANDHELD GRINDING PROCESS

[*]Qingsong Chen[+], Hansheng Lin[+], Bin Xiao[+], Daniel E. Welcome[++], Jacob Lee[+++],Guiping Chen[+], Shichuan Tang[++++], Danying Zhang[+], Guoyong Xu[+], Maosheng Yan[+], Hua Yan, Xueyan Xu[++], Hongying Qu[+], Ren G. Dong[++]

[+]Guangdong Province Hospital for Occupational Disease Prevention and Treatment, Guangdong Provincial Key Laboratory of Occupational Disease Prevention and Treatment, Guangzhou, Guangdong 510300, China

[++]Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, WV 26505, USA

[+++]Advanced Sporting Goods Co., LTD., Dongguan, Guangdong, China

[++++]Key Laboratory of Occupational Health and Safety, Beijing Municipal Institute of Labor Protection, Beijing 100054, China

Introduction

The vibrations of handheld workpieces such as golf club heads during their grinding process can be effectively transmitted to the hands, especially the fingers. As a result, vibration-induced white finger (VWF) has been observed among some workers performing the grinding/polishing tasks of the handheld workpieces[1]. To control this occupational disease, the objectives of this study are to identify the major vibration sources for the handheld workpieces, to understand the basic characteristics of the vibration, and to propose potential approaches for reducing the vibration exposure.

Methods

Fig. 1 shows a typical work station for the fine grinding of a golf club head, together with the setup for vibration measurement. The club head is held by two hands, primarily controlled by the fingers, during the grinding process. A portable vibrometer (Svantek, SV106) and its probe (held by the fingers) equipped with a tri-axial accelerometer were used to measure the club head vibration. Two typical belt grinding machines, one with a large grinding driving wheel (Fig. 1) and the other with a small grinding driving wheel, were used in the experiment. The experiment was conducted at three different operation speeds (1,200, 1,800, and 2,400 RPM).The vibrations of two typical models of gold club heads (titanium head and stainless steel head) were measured. Three experienced workers participated in the experiment. During the measurement, each worker was advised to conduct his/her normal grinding task. Three trials were performed for each test treatment. During each trial, three club heads were ground, which lasted between 8 and 20 seconds, depending on the amount of the grinding required for each of the club heads and the skill and efficiency of each worker. The vibration on each of the grinding machines with and without performing the grinding was also measured. Besides above-mentioned variables, a few other factors such as applied hand forces, machine foot pad, and driving wheel condition were also examined in this experimental study.

Fig. 1: The measurement of a golf club head vibration during its fine grinding

Results and Discussion

Fig. 2 shows examples of the one-third octave bands vibration spectra measured on the club heads and the machine with the large driving wheel. The vast majority of the peak frequencies in the spectra are associated with the machine operation speed. For example, the peak frequencies at 31.5, 63, and 100 Hz shown in Fig. 2(a) are approximately equal to certain integer multiples of the speed-related frequency (e.g., 1,800 RPM/60 seconds = 30 Hz). These peak frequencies become 40, 80, 125 Hz when the speed is increased to 2,400 RPM, as shown in Fig. 2(b). Also interestingly, these peak frequencies are observed in both machine and workpiece vibration spectra, especially in the case shown in Fig. 2(b). These observations suggest that the workpiece vibration is largely affected by the machine vibration. On the other hand, the machine vibration is not significantly affected by the grinding process, as the machine vibration spectra measured with and without performing the grinding, respectively named as Subject Machine vibration and Free Machine vibration in Fig. 2(b), are almost identical below 630 Hz. This is because the club head mass (<0.3 kg) and the hand effective mass (< 1 kg) are much less than the driving wheel mass (11 kg) and the machine mass (350 kg) and the dynamic forces generated in the fine grinding process are too small to significantly change the vibration of this machine. However, the grinding on the small-wheel machine affected the machine vibration for frequencies higher than 63 Hz. This may be because the mass of the driving wheel is smaller than that on the other machine and a larger vibration was generated on the small-wheel machine. The influenced frequency range also suggests that the grinding itself mostly generated high frequency vibration. This is also evident from the significant grinding effect on the vibration of the large-wheel machine at frequencies higher than 630 Hz. These observations suggest that the club head vibration results from its response to combined machine and grinding vibrations. Theoretically, the response depends not only on the excitations but also on the dynamic properties of each club head and its constraints. The tested club heads have shell structures with a low damping property. They are likely to have some high-frequency resonances. This explains the large high-frequency responses shown in Fig. 2. The identified vibration sources and characteristics suggest that the vibration exposure in the club head grinding can be controlled by reducing machine vibration, changing the dynamic properties of the club head by attaching damping materials to the club head, and mitigating the vibration transmissions in its pathway.

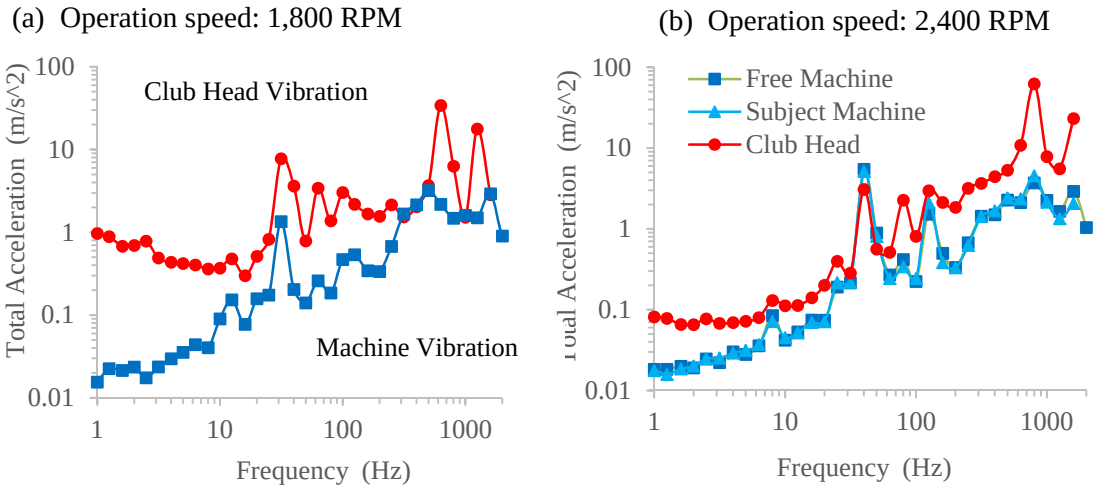


Fig. 2: Comparison of the machine and workpiece vibration spectra

References

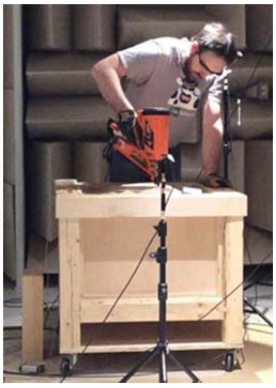
1. Chen, Q.S., Xiao, B., Yang, A.C., Lin, H.S., Yan, H., Lang, L., Yan, M.S., Chen, G.P., Zeng, F.S., Cao, X.Q., 2015. The characteristics of vibration-induced white finger in workers polishing handheld pieces in the southern subtropics of china. The Proceedings of the 13th International Conference on Hand-Arm Vibration, Beijing, China, 19-20.

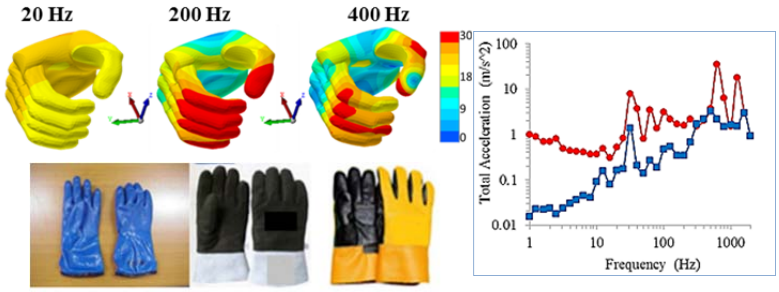
Program & Proceedings
6th American Conference on Human Vibration

Venue: Marquette University Alumni Memorial Union

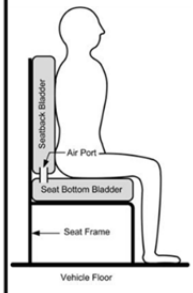
Teaming physicians / health professionals, engineers and research scientists in academia, government and industry to understand and prevent vibration disease and engage the next generation of students

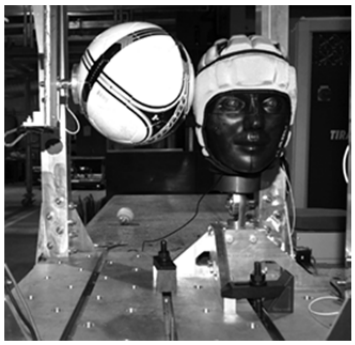
Distinguished Keynote Speaker: Massimo Bovenzi, MD

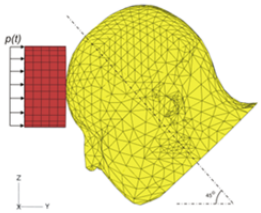


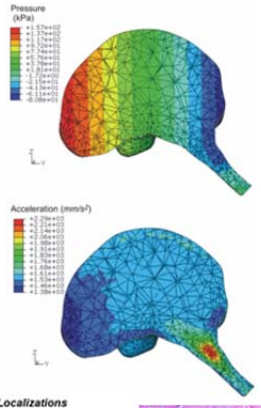


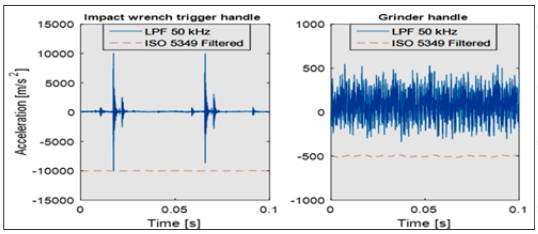
Samples of the Hand Arm, Whole Body and Impact Vibration Research Studies

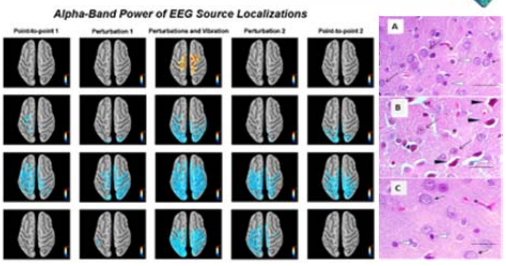












Proceedings of the

Sixth American Conference on Human Vibration

June 8 – 10, 2016

Jointly hosted by the

Medical College of Wisconsin

and

Marquette University

Venue
Marquette Alumni Memorial Union
Milwaukee, Wisconsin, U.S.A

Co-chaired by

Danny A. Riley, PhD
Department of Cell Biology, Neurobiology & Anatomy
and Physical Medicine & Rehabilitation
Medical College of Wisconsin

and

Brian D. Schmit, PhD
Department of Biomedical Engineering
Marquette University
Medical College of Wisconsin

http://www.mcw.edu/American-Conference-on-Human-Vibration-ACHV.htm