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MEASUREMENT AND ANALYSIS OF VIBRATION OF HAND-HELD TOOL

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1. INTRODUCTION

It is to be considered that percussive tools, such as impact wrenches and rock drills generate impulsive vibration with high frequency components (above 1 KHz). These percussive tools may have detrimental effect on human body comparing with non-percussive ones. Using these percussive tools cause relatively high preferences of vascular and neurological disturbances. Gemne[1] pointed out that a current weighting curve is based on the perception responses of human body and the subjective reaction dose not reflect the functional disturbance in vibration-induced white finger. However, application of the present ISO 5349[2] and JIS C-1511[3] of frequency range is from 8 Hz to 1 KHz (center frequency) and the weighting curve shows that high frequency vibrations relatively contributes less effective to evaluate the vibrations comparing to low frequency ones.
We tried to show the frequency components of the hand-held tools using in Japan, especially, percussive tools and difference of acceleration levels between frequency band width such as bands of 1/3 octave, a band of ISO 5349(8 Hz- 1 KHz) and more wide range.

2. HAND-HELD TOOLS

Hand-held power tools used in the present study were impact wrenches, rock drills of leg type, concrete breakers which were selected as typical tools generating more shock-type vibrations and a grinder generating more steady-state vibrations. Both impact wrenches A and B have no protection handle from vibrations. The wrench A is for 6 mm bolts and the wrench B is

for 9 mm bolts, drills with and without protector and breakers with and without protectors and a grinder shown in Table 1.

Hand-held tools
impact wrench A
impact wrench B
leg drill (without protector)
leg drill (with protector)
breaker (without protector)
breaker (with protector)
grinder

Table 1

3. MEASUREMENT AND ANALYSIS

Measurement

Measurement instruments of vibration acceleration were a vibration transducer(PV-93, 21 * 27 * 16 mm^3 ,28gr) which can measure in three directions simultaneously, and a vibration meter(VM-19A,RION Co. Japan). This vibration meter measures r.m.s. accelerations and this value is expressed in terms of a vibration acceleration level(VAL; without frequency weighted) and vibration level(VL; with frequency weighted[3]) in decibels relative to 10^{-5} m/s^2 r.m.s.. A data recorder DAT type(RD-101T, TEAC Co. Japan) also is used to store vibration signals of vibration acceleration shown in Fig. 1-a. The transducer was mounted firmly with hose clamps on a handle of the hand-held tool. Time of operation of the tools varies 1 min. to 1.3 min. depending on types of tools and work condition. Measurements of vibrations at the handle of impact wrenches and a grinder were followed by ISO-8662[4] . For breakers, measurements were made on the normal work condition using a concrete block(3 * 2 * 1 m^3) and for the leg drill using a granite stone(1 m^3).

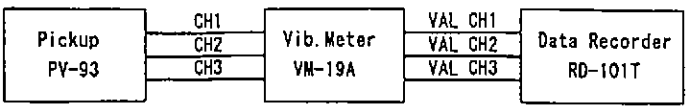


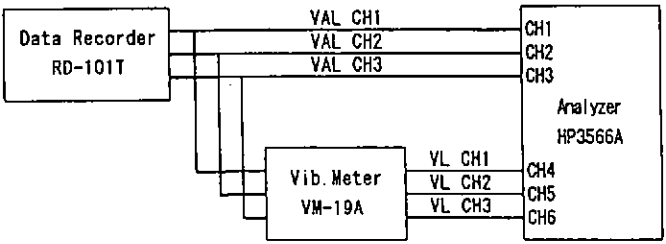
Figure. 1-a Schematic Diagram for Measurement

Analysis

The vibration acceleration signals were analyzed with the data recorder, vibration meter and an analyzer. The vibration meter used as a DC amplifier and a filter with frequency weighted(VL) and the analyzer

(HP3566A, HEWLETT PACKARD) in Fig.1-b. Time of analysis of the signals with the analyzer was 60 seconds over the operation time of the tools. A power spectrum analysis was performed from 4 Hz to 3.2 KHz as a frequency analysis. In order to compare overall values of vibration spectrum components of the tools, we tried to use three frequency ranges, an 1/3 octave band (JIS C 1511: center frequency ; 8Hz - 1.2KHz), 8Hz - 1.4 KHz and 4Hz - 3. 2 KHz(maximum range of the analyzer). Crest factors of signals of all tools were calculated.

Figure 1-b Schematic Diagram for Analysis



4. RESULTS

Wave form

Acceleration time histories are shown as examples of the vibration tools in Fig.2-a,b. Fig. 2-a shows wave form of the impact wrench A (without vibration protector) and the grinder in the Y direction. Fig.2-b shows wave form of the breaker (without protector) and the breaker (with protector) in the Y direction. In the impact wrench A and the breaker(without protector), shock type waves are seen, while the grinder has less shock waves.

Frequency component

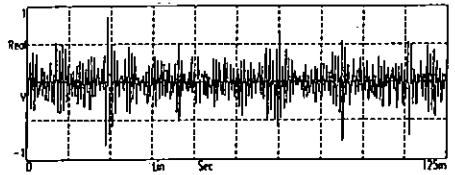
Fig. 3-a,b shows power spectrum of vibration of the impact wrench, grinder and breaker(without and with protector) in the Y direction. The dominant frequency range of the vibration are between 1 KHz and 2.5 KHz in the impact wrench A. In case of the grinder, the fundamental frequency is 100 Hz and its has less components over 1KHz. In the breaker(without protector) fundamental frequency is about 17 Hz and the dominant frequency range is 500 Hz to 2 KHz in X and Y directions. In the breaker(with protector), components of higher frequency are reduced.

Effect of frequency band on the VAL and VL values

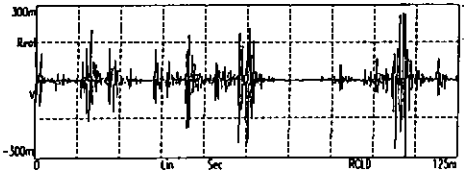
In this study, we used three frequency bands to analyze frequency

Figure 2-a

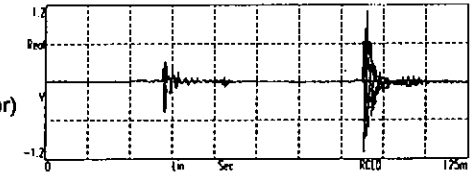
Grinder



Impact wrench A
(without protector)



Breaker
(without protector)



Breaker
(with protector)

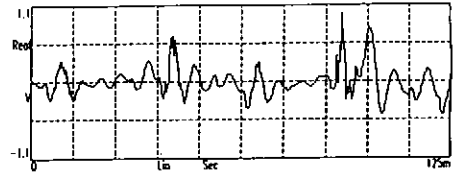
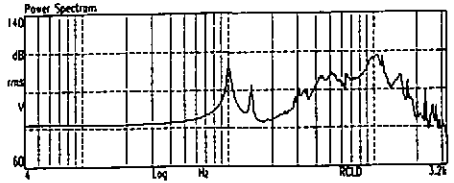
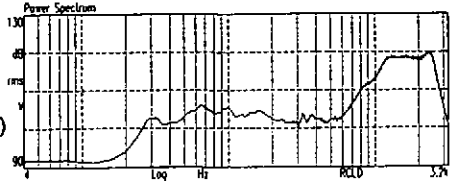


Figure 2-b
Power Spectrum

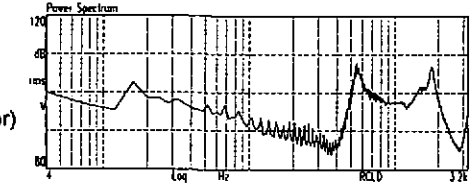
Grinder



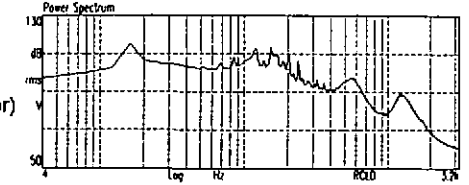
Impact wrench A
(without protector)



Breaker
(without protector)



Breaker
(with protector)



components, a 1/3 octave band(8Hz-1.25KHz), 8Hz-1.4KHz and 4Hz-3.2 KHz. VL values of all tools used here are not affected by the frequency band. However, VAL values of the wide band(4-3.2KHz) show more large values from 2 to 9 dB depending on vibration direction than that of the narrow band in the impact wrenches and the breaker without protector. It implies that these tools have components of higher frequency.

Crest factor

Crest factors of the vibrations were calculated. In case of VAL of the tools, crest factors of all tools except the leg drill(with protector) and the grinder have over 9 value which means border value of the signals between steady-state vibration and shock-type vibration in whole-body vibration. An impact wrench and breaker have crest factors over 15 in VAL and over 10 in VL in X direction.

5. DISCUSSION

Vibration acceleration of seven hand-held tools were measured and analyzed here. The tools were selected to be thought to contain shock-type vibration or high frequency vibration. Only a grinder was selected as an example of the tools which dose not include the high -frequency vibration. Measurement of shock has problems as Griffin[5] pointed out that d.c. shifts are excited and use of a mechanical filter to isolate the transducer from high magnitude with high frequency may be essential. Although the measurement of the vibrations was made without the mechanical filter here, the d.c. shifts and any distortion of the time histories of the vibration were not found during the measurements in this study.

From the results of the measurement and analysis of the study, it was found the fact that there are tools containing high-frequency vibrations as predicted. Gemne introduced in his literature review[1] that neurological deficiency was observed in the hand of a group of dentists and dental technicians contain ultra-high frequencies(up to 40 KHz). Gemne also introduced Louda's paper that separate frequency-weighting curves must be developed for various vibration with high frequency.

As these papers pointed out that high frequency vibration is an important factor in consideration of hand-arm vibration disease and from the present results which there are hand-held tools with high frequency components,

we need to reconsider these high frequency vibration from view points of measurement, effects on human body and evaluation of vibrations. Also revision of weighting curve of present ISO should be one of the purpose to develop a relevant dose-response relationships based on not vibration perception but on the functional disturbance in vibration induced white finger as pointed out by Gemne.Although, from vibration control it is not difficult to reduce vibration acceleration level in high frequency over 1 Hz, it is important to know that there are tools with high frequency vibration and impulse vibration. In addition to this, the effects of the impulsive vibration on man should be investigated to establish the relevant evaluation method.

6. CONCLUSION

1) There are hand-held tools which have high frequency vibrations above 1KHz especially percussive tools such as impact wrenches and breakers without anti-vibration protectors.
2) Some percussive tools have crest factors over 15 VAL(unweighted acceleration) and over 10 in VL(weighted acceleration).
3) VAL values with a wide band filter(8Hz-3.2KHz) showed larger levels by about 10 dB than that with a narrow band filter(8Hz-1.25KHz).
4) It must be reconsidered shocks and vibrations with high frequency to find the functional disturbance caused by these vibrations and to establish the relevant weighting curves and an evaluation method of these vibrations.

References

1) G. Gemne, R. Lundstrom and J-E. Hansson, "Disorders induced by work with hand-held vibrating tools - A review of current knowledge for criteria documentation-", Arbete och Halsa(1993).
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3) JIS C 1511 "Vibration level meters for hand tools"(1979), Japanese Industrial Standard.
4) ISO 8662-4 "Hand-held portable power tools-Measurement of vibrations at the handle- Part 4: Grinding machines
5) M.J. Griffin, Handbook of human vibration (Academic,Press,1990)