づいた振動暴露管理を導入した際のレイノー現象有症率の予測を行った。

振動暴露対策値の A(8)=2.5m/s^2 rms の場合には、日本産業衛生学会の A(8)＝2.8m/s^2 rms より低い値であり、10 年間の振動暴露でもレイノー現象有症率は 2.3%で、A(8)＝2.8m/s^2 rms に 10 年間振動暴露を受けた場合の 2.6%より低く抑えられると予測された。またレイノー現象有症率が 2.6%に達するには 11.8 年と予測された。10 年間の振動暴露でもレイノー現象有症率 2.3%は、日本人男性の調査報告をまとめて求められた推測値（男性 1.9%（95%信頼区間：1.4 − 2.3%））の 95%信頼区間の最大値と同じであった。したがって EU 振動指令の A(8)=2.5m/s^2 rms の振動暴露対策値を振動暴露管理の目標とすることは、わが国の振動暴露管理の指針としても妥当性を有すると考えられる。

一方、EU 振動指令の振動暴露限界値の A(8)= 5.0 m/s^2 rms の場合には、10 年間の振動暴露でレイノー現象有症率は 4.4%となり、非振動性レイノー現象有症率の最大３％を若干超える危険性を有していた。また A(8)＝2.8m/s^2 rms に 10 年間暴露された場合のレイノー現象有症率に 4.2 年で達すると予測された。EU 振動指令では、この振動暴露限界値は超えてはならない、越える場合には暴露低減対策を即刻とることとされている。我が国でもこうしたレイノー現象有症率を増す危険性を有することを配慮しながら、振動暴露限界値として振動暴露管理を実施することは、実際的であると考えられた。

現在、わが国では第 10 次労働災害防止計画で「騒音、振動発生機器について製造業者による騒音・振動レベルの表示の導入を図る」として、振動リスク評価の基礎となる工具振動レベルの表示の導入が計画されている。この振動レベルの表示によって、工具の振動レベルの情報提供がすすみ、より低振動の工具への導入が促進されることが期待される。こうした動きをさらに促進するために、EU 振動指令のような振動暴露対策値として A(8)=2.5m/s^2 rms、振動暴露限界値として A(8)= 5.0 m/s^2 rms などによる振動暴露管理のさらなる導入が望まれる。

E. 結論

振動暴露管理として、EU 振動指令の振動暴露対策値の A(8)=2.5m/s^2 rms を導入した場合には、日本産業衛生学会の A(8)＝2.8m/s^2 rms より低い値であり、10 年間の振動暴露でもレイノー現象有症率は 2.3%で、日本人男性の調査報告をまとめて求められた推測値（男性 1.9%（95%信頼区間：1.4 − 2.3%））の 95%信頼区間の最大値と同程度であった。したがって EU 振動指令の A(8)=2.5m/s^2 rms の振動暴露対策値を振動暴露管理の目標とすることは、わが国の振動暴露管理の指針としても妥当性を有すると考えられる。一方、EU 振動指令の振動暴露限界値の A(8)= 5.0 m/s^2 rms の場合には、10 年間の振動暴露でレイノー現象有症率は 4.4%となり、非振動性レイノー現象有症率の最大３％を若干超える危険性を有していた。EU 振動指令では、この振動暴露限界値は超えてはならない、越える場合には暴露低減対策を即刻とることとされている。わが国でもこうしたレイノー現象有症率を若干増す危険

性を有することを配慮しながら、振動暴露限界値として振動暴露管理を実施することは、実際的対応であると考えられた。

F. 研究発表

論文発表　なし

学会発表　なし

G. 知的所有権の取得状況

なし

表 1. 日本における一般集団での非振動性レイノー現象の有症率

	対象者数		年齢範囲		レイノー現象有症率	
	男性	女性	男性	女性	男性	女性
Harada et al. (1991)	1875	1998	20-69	20-69	1.4%	1.9%
Inaba et al. (1989)	149	262	20-89	20-89	1.3%	1.5%
Mirbod et al. (1994)	1027	1301	30-59	30-59	2.7%	3.4%

全調査からのレイノー現象有症率は、男性　1.9%(95%信頼区間;1.4-2.3%)、女性 2.4%(1.9-2.9%)

表 2. 日本における一般集団での性・年齢別非振動性レイノー現象有症率

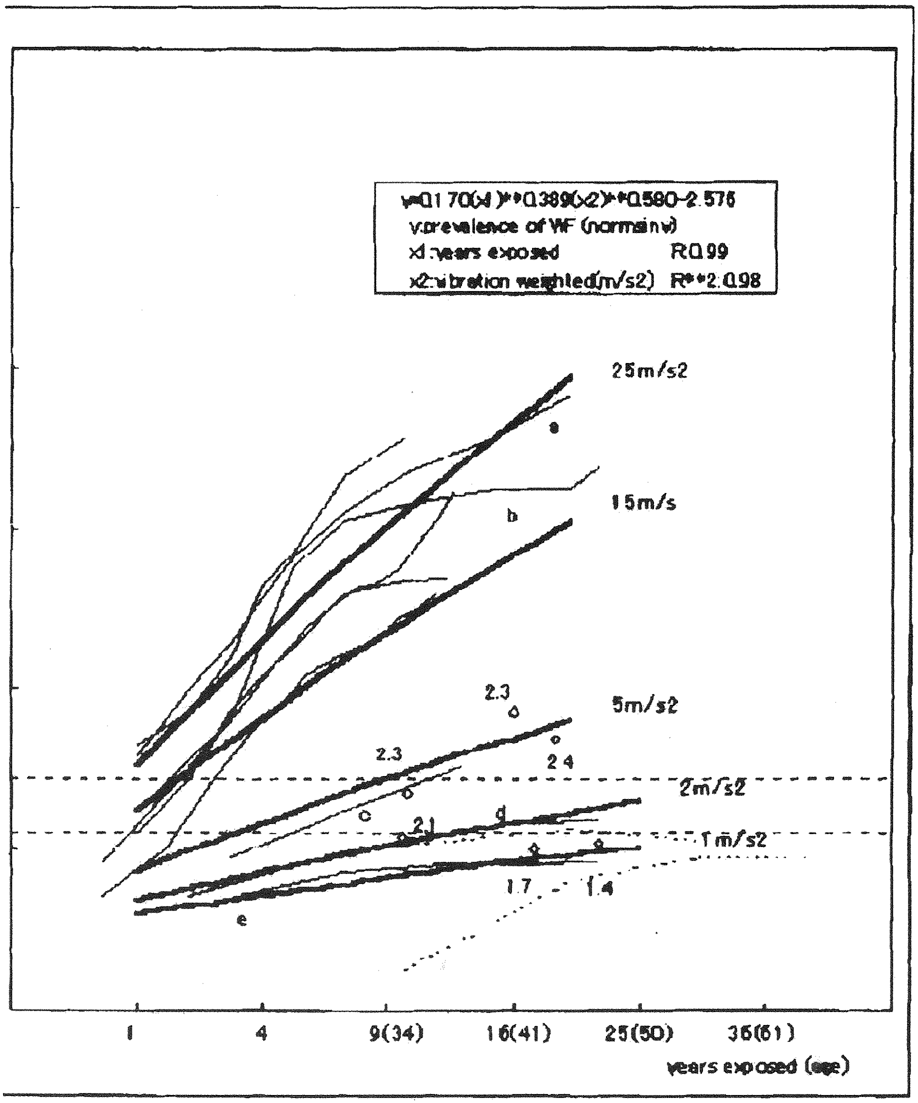
(Harada et al. 1991, Mirbod et al. 1994)

年齢	レイノー現象有症率 (95%信頼区間) 男性	 女性
30-39	1. 1% (0. 3-1. 9%)	3. 1% (1. 5-4. 6%)
40-49	2. 3% (1. 2-3. 3%)	3. 0% (1. 8-4. 2%)
50-59	2. 3% (1. 3-3. 4%)	2. 3% (1. 5-3. 2%)

表 3. 日本における低振動暴露群でのレイノー現象有症率

	工具 機械	振動加速度 (1 軸)	暴露平均 時間／日	年	レイノー 現象
Mirbod et al. 1994	digging[a)]	1.6-2.1 m/s^2	5	22	2.5%
Mirbod et al. 1994	aircraft[b)]	2.3-2.5 m/s^2	4	17	2.3
Mirbod et al. 1994	chain-saw	2.7-5.1 m/s^2	3	19	9.8
Tominaga, 1995	motor-cycle	1 -2 m/s^2 [c)]	4[c)]	12	1.8
Tominaga, 1995	motor-cycle	2-3 m/s^2 [c)]	4[c)]	12	3.0
Matsumoto et al. 1981	motor-cycle	1.6 m/s^2	2.5	9.7	2.7
Futatsuka et al. 1984	various	3.2 m/s^2 [c)]	4[c)]	10	5.0
Futatsuka et al. 1984	various	3.2 m/s^2 [c)]	4[c)]	16	12.8

a);job b);factory c);equivalent value for 4hrs c);estimated value theoretically



Harada et al. 2000

図１．手腕振動暴露強度および年数とレイノー現象有症率との関連性

Ⅲ．研究成果の刊行に関する一覧表

Ⅲ. 研究成果の刊行に関する一覧表

書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書　籍　名	出版社名	出版地	出版年	ページ
なし							

雑誌

発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
Maeda, Setsuo., Keller, Tony	Multi-Axis Hand-Arm Vibration Testing&Simulation at the National Institute of Industrial Health, Kawasaki, Japan	Proceedings of First American Conference on Human Vibration Morgantown, West Virginia, U.S.A		99-100	2006年6月5日
Hosoya, Naoki. , Maeda, Setsuo	Establishment of an Experimental System For Measuring Biodynamic Response of Hand-Arm.	Proceedings of First American Conference on Human Vibration Morgantown, West Virginia, U.S.A		136-137	2006年6月5日
Sakakibara, Hisataka., Maeda, Setsuo	Measurement of head vibration during operating pneumatic tools in quarry work	Proceedings of 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo		38-41	2006年8月2日

Shibata, Nobuyuki., Maeda, Setsuo	Effects of environmental condition on biodynamic response in hand-arm system -Finite element modeling	Proceedings of 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo		84-93	2006 年 8 月 2 日
Maeda, Setuo., Ozaki, Masakazu	Comparison of human vibration measurement by a laser doppler vibrometer and an accelerometer	Proceedings of 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo		124-131	2006 年 8 月 2 日
前田節雄	**手持動力工具振動値のラベリング方法について**	**日本産業衛生学会東海地方会、第２０回振動障害研究会資料**		1-35	平成 19 年 2 月 24 日

Ⅳ．研究成果の刊行物・別刷

IV．研究成果の刊行物・別刷

1．Maeda, Setsuo., Keller, Tony. (2006) Multi-Axis Hand-Arm Vibration Testing&Simulation at the National Institute of Industrial Health, Kawasaki, Japan. First American Conference on Human Vibration Morgantown, West Virginia, U.S.A., pp 99-100.

2．Hosoya, Naoki. , Maeda, Setsuo. (2006) Establishment of an Experimental System For Measuring Biodynamic Response of Hand-Arm. First American Conference on Human Vibration Morgantown, West Virginia, U.S.A., pp 136-137.

3．Sakakibara, Hisataka., Maeda, Setsuo. (2006) Measurement of head vibration during operating pneumatic tools in quarry work. 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo, pp 38-41. Shibata, Nobuyuki.,

4．Maeda, Setsuo. (2006) Effects of environmental condition on biodynamic response in hand-arm system -Finite element modeling-. 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo, pp 84-93.

5．Maeda, Setuo., Ozaki, Masakazu. (2006) Comparison of human vibration measurement by a laser doppler vibrometer and an accelerometer. 14th Japan Conference on Human Response to Vibration T.M.U., Hachioji, Tokyo, pp 124-131.

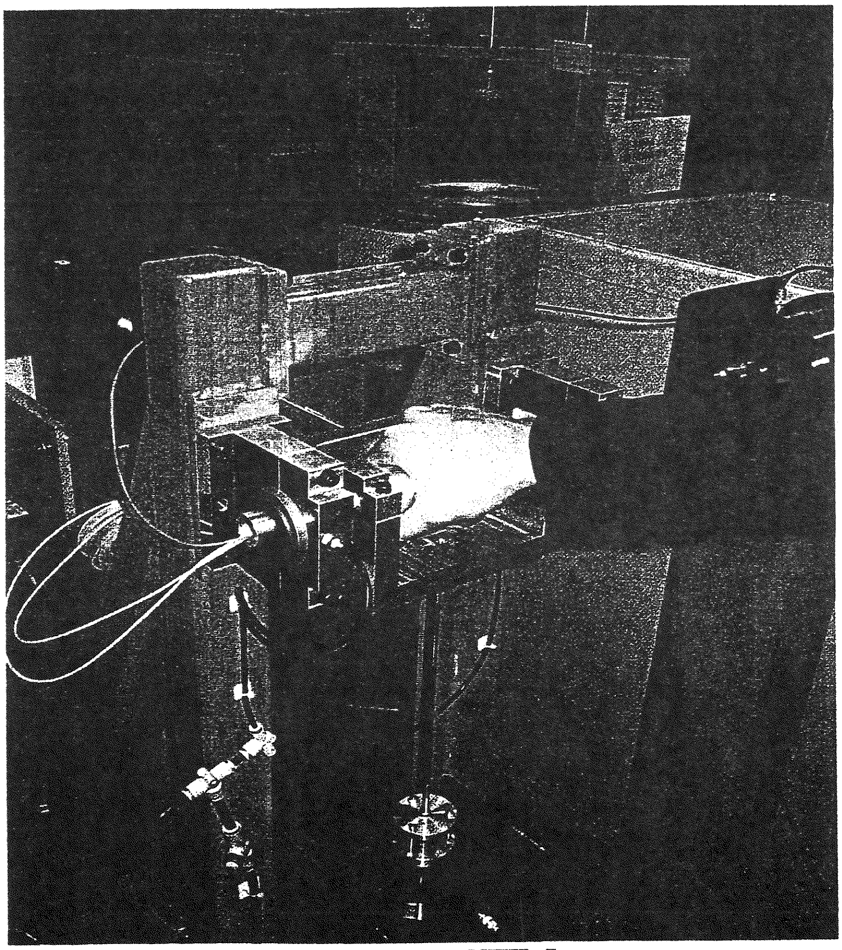
6. **前田節雄：手持動力工具振動値のラベリング方法について、日本産業衛生学会東海地方会、第２０回振動障害研究会資料、pp. 1-35、**平成 19 年 2 月 24 日.

MULTI-AXIS HAND-ARM VIBRATION TESTING & SIMULATION AT THE NATIONAL INSTITUTE OF INDUSTRIAL HEALTH, KAWASAKI, JAPAN

Setsuo Maeda, National Institute of Industrial Health, Kawasaki, Japan
Tony Keller, Spectral Dynamics, Inc., San Marcos, California, U.S.A.

Introduction

Hand-Arm Vibration Syndrome (HAVS) was identified as early as 1918 in Bedford, Indiana in the U.S. Since then much research work has been done around the world in the areas of medical, epidemiological, engineering and legal aspects of HAVS. In Japan, much of the pioneering work in this field has been performed by Dr. Setsuo Maeda and his staff at the National Institute of Industrial Health (NIIH) in Kawasaki. Most recently, reports of work done by this group and by Dr. Ren Dong[1] of NIOSH in the U.S., as well as many other suppliers and Japanese practitioners were presented at the 13th Japan Group Meeting on Human Response to Vibration held in Osaka[2] during August 3-5, 2005.



Patient grasping test handle at NIIH, Japan

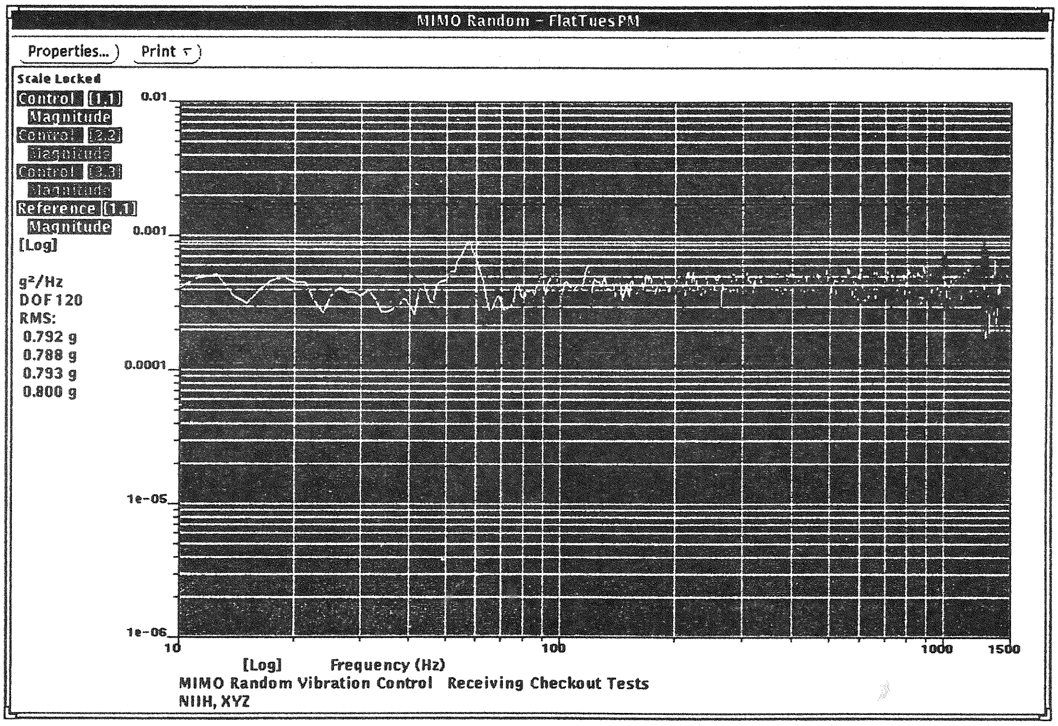
The laboratory at NIIH has been at the forefront of much of the testing technology and instrumentation verification involved in the latest HAVS research which is taking place. An example of this is the recently installed 3-axis vibration simulator in the NIIH laboratory. What follows is a brief description of this system and some results obtained to date.

Methods

Specific methods of measurement and analysis were under development as this abstract was prepared. The presentation may include actual patient response data if it is available at that time.

Results

Results of simultaneous X, Y, Z controlled excitation, like this example, are given.



X, Y, Z Responses controlled from 10 to 1,500 Hz

Discussion

Development is continuing on a modified special handle with embedded Force and Acceleration transducers to understand fully the patient HAVS responses.

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ESTABLISHMENT OF AN EXPERIMENTAL SYSTEM FOR MEASRING BIODYNAMIC RESPONSE OF HAND-ARM

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Setsuo Maeda, National Institute of Industrial Health (NIIH), Kawasaki, Japan

Introduction

This paper addresses establishment of an experimental system for measuring biodynamic response (BR) of hand-arm system at the NIIH in Japan. BR measurement system at the NIIH is nearly equivalent to NIOSH installed system. The feasibility of the system is examined through the apparent mass (AM) measurement of the empty handle and a set of calibration masses.

Apparatus

The grip force was measured by using the handle shown in Fig. 1. The handle has two force sensors (KISTLER, 9212) and one accelerometer (PCB, 356A12). A low-pass filter with 5 Hz cut-off frequency was used to the grip force from measured force signal. Figure 2 shows BR measurement system in this study. The push or pull force at the handle was measured by using the force plate (KISTLER, 9286AA). The grip force and the push / pull force were displayed on a monitor. The shaker (IMV, VE-100S) is used to vibrate the hand-arm system along the forearm axis (Z_h direction) (ISO 10068, 1998; ISO 5349-1, 2001). In most situations force actions for operating tools are expressed by grip, push, pull and combined these actions. These actions can be simulated in the test system. AM was obtained by performing H1 estimator in the PULSE™ system (B&K, 3109) and it is denoted at the one-third octave band center frequencies.

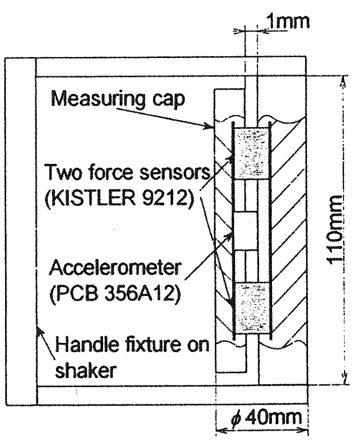

Fig. 1 Instrumented handle of the system

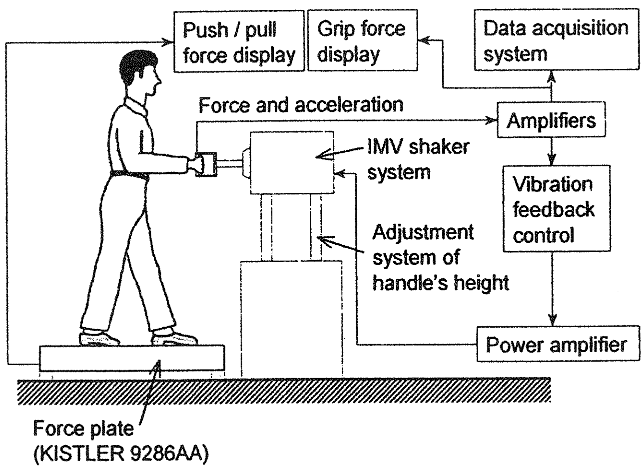

Fig. 2 Measurement system at the NIIH

Methods

In order to investigate the reliability of the system, AM measurement of the handle was performed. It is assumed that the handle is rigid in the upper limit of adoptive frequency range in this study. This assumption is validated in AM measurement of the empty handle. A pseudo-random vibration in the frequency range of 10 to 1,250 Hz was used and its amplitude is 1.0 $(m/s^2)^2/Hz$ with a flat power spectral density (PSD) in the experiment.

Measured AM includes the mass effect of the measuring cap in a subject experiment. Compensated apparent mass $AM_c(\omega)$ is obtained by Eq. (1) [1-2].

$$AM_c(\omega) = AM_{total}(\omega) - AM_{cap}(\omega) \quad (1)$$

where $AM_{total}(\omega)$ is measured response with the mass of the measuring cap and BR of a subject, $AM_{cap}(\omega)$ is the response of measuring cap in an empty handle test. In this study it is assumed that $AM_{total}(\omega)$ is the response with attached small piece of metal to the measuring cap by adhesive tape. Eight pieces (1, 2, 3, 4, 5, 10, 15 and 20g) of metal were used in the experiment.

Results and Discussions

The measured AM of the empty handle differences between measured and true values are less than 3%. Since resonant frequency is higher enough frequency range of measurement (12.5 – Hz), the assumptions seem to hold in the frequency range of measurement. The calibrations of the measuring cap's mass shown in Fig. 3. The measured pieces of generally agree with the true mass value. measured mass values of over 10g are than the true mass value in the high frequency range (>600Hz).

AM the than 1,000 are mass The bigger

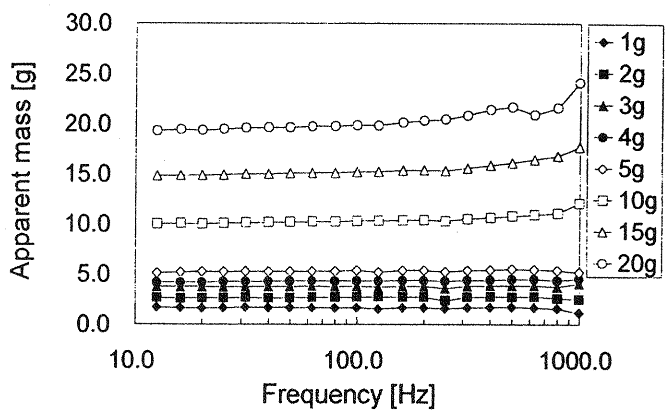

Fig. 3 Mass compensation results

The amplification of the response seems increases with the increase in the metal mass. This is likely because each piece of metal is resiliently attached to the measuring cap by adhesive tape and the metal and tape form a local 1D system. The resonant frequency of the system reduces with the increase in the mass value. This further supports the validity of the measurement system and the mass cancellation method.

Conclusions

Throughout the course of this study, several conclusions are obtained as follows:

(1) A BR experimental system for measuring biodynamic response of hand-arm system and vibration exposure tests was established in NIIH.

(2) The instrumented handle of the system was validated through the AM measurement.

(3) The mass of the measuring cap in the AM measurement was well compensated by the mass cancellation method, which confirms its validity.

Acknowledgements

The authors acknowledge the assistance of staff at NIOSH, Dr. Dong, R. G. and Mr. Welcome, D. E. Their help is greatly appreciated.

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MESUREMENT OF HEAD VIBRATION DURING OPERATING PNEUMATIC TOOLS IN QUARRY WORK

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Abstract

The vertical head vibration while operating a rock drill and a chipping hammer in stone quarry work were measured with an accelerometer (Bruel & Kjaer type 8307, weighted 0.5g) attached to a tooth impression set in the upper central incisors of subjects. The digitized vibration data was analyzed by a personal computer with *HVLab* software package. Frequency-weighted r.m.s. acceleration vales of the handle vibration of a rock drill ranged from 5.84 to 9.47 m/s^2, and the head vibration of the operators were 0.55 to 1.14 m/s^2. The handle vibration of a chipping hammer ranged from 3.12 to 5.01 m/s^2, while the head vibration were 0.13 to 0.23 m/s^2. The present measurements demonstrated that the head of operators was vibrated while they use pneumatic hand-held tools such as a rock drill and a chipping hammer. The effect of such head vibration on operators may be necessary to be investigated.

Introduction

It is experimentally demonstrated that vibration is liable to be transmitted from the hand to the head at low frequencies. Vibration of pneumatic tools such as rock drills and chipping hammer contains its low frequency components dominantly. While operating such pneumatic tools, the operator's head is expected to be vibrated by the hand-transmitted vibration. If the head is vibrated heavily, it might possibly affect the neck and the other part of the body. The aim of the present study was to investigate the head vibration of operator during using a rock drill and a chipping hammer in stone quarry work.

Presented at the 14th Japan Conference on Human Responses to Vibration,
Held in T.M.U., Hachioji, Tokyo, Japan, Aug 2nd to 4th, 2006.

Method

The vertical head vibration while operating a rock drill and a chipping hammer in stone quarry work were measured with an accelerometer (Bruel & Kjaer type 8307, weighted 0.5g) attached to a tooth impression set in the upper central incisors of subjects. The tooth impression was made from resin to be fitted to the upper incisors of each subject beforehand. The size was about 20mm long by 15mm wide by 12mm thick, and the weight was about 2g. The surface was flat except for the top and sides, where the shape of the incisors was impressed.

The vertical head vibration and the operators and the handle vibration of the pneumatic tools were measured simultaneously, when pushing and operating a rock drill and a chipping hammer to a big stone.

The acceleration of tools was measured with a triaxial accelerometer (Bruel & Kjaer type 4366 and 8301) attached to the handle of the tools. The acceleration signals on a tooth impression set and the handle of the tools were conditioned by charge amplifiers (Bruel & Kjaer type 2626 or 2635, respectively) and then were low-pass filtered at 1670Hz to prevent aliasing and converted to digital form at a rate of 5000 samples per second. The digitized vibration data was analyzed by a personal computer with *HVLab* software package.

Table. Unweighted and frequency-weighted r.m.s. acceleration vales (m/s^2) of the tools and the head of subjects while operating tools

	Subject-A			Subject-B		
Rock drill						
Handle X-ahw	3.04	3.52	3.23	3.99	5.70	3.23
Y-ahw	3.31	3.34	3.37	3.35	5.32	3.75
Z-ahw	3.89	3.68	3.51	3.42	5.38	3.66
a_{hv}	5.94	6.09	5.84	6.23	9.47	6.16
Head-aw	0.61	0.59	0.55	0.97	0.64	1.14
Chipping hammer						
Handle X-ahw	1.84	2.88	2.03	1.98	1.85	1.55
Y-ahw	2.88	3.14	3.21	1.85	2.86	3.48
Z-ahw	2.03	2.74	3.26	1.55	2.39	3.23
a_{hv}	3.98	5.01	5.01	3.12	4.16	4.99
Head-aw	0.18	0.23	0.22	0.21	0.20	0.13

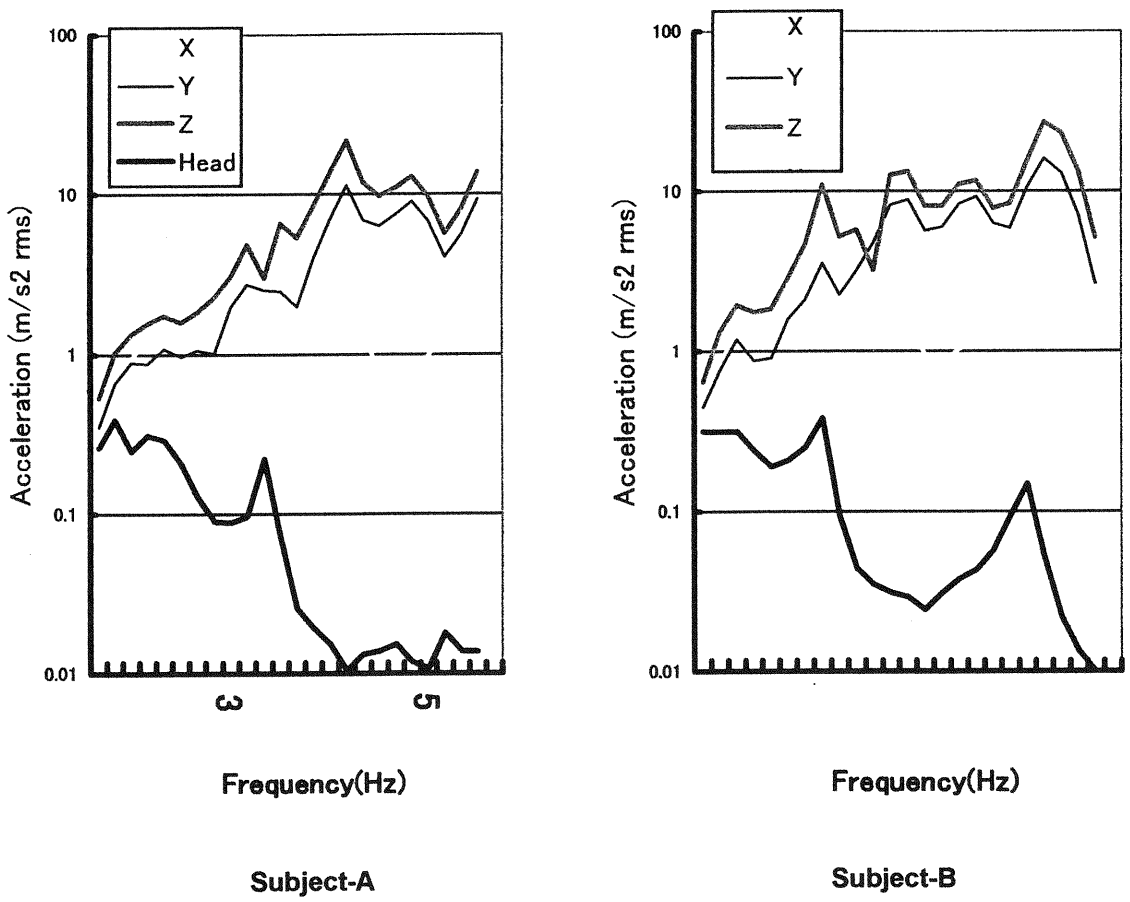

Figure. Rock-drill handle and head vibration during operating a rock drill

Results

Frequency-weighted r.m.s. acceleration vales of the tools and the head while operating a rock drill and a chipping hammer were shown in Table. The handle vibration (a_{hv}) of a rock drill ranged from 5.84 to 9.47 m/s^2, and the head vibration of operators were 0.55 to 1.14 m/s^2. On the other hand, the handle vibration of a chipping hammer ranged from 3.12 to 5.01 m/s^2, while the head vibration was 0.13 to 0.23 m/s^2. Examples of handle vibration and head vibration measured while operating a rock drill were shown in Figure.

Discussion and Conclusions

The present measurements demonstrated that the vibration of pneumatic tools can be transmitted to the head of operators particularly and their head is vibrated. The transmissibility was particularly high at low frequency. The head of operators was more greatly vibrated during the use of a rock drill than a chipping hammer. The effect of such head vibration on operators may be necessary to be investigated.

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EFFECTS OF ENVIRONMENTAL CONDITION ON BIODYNAMIC RESPONSE IN HAND-ARM SYSTEM - FINITE ELEMENT MODELING -

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Abstract

Users of vibrating hand tools and machines are occupationally exposed to hand-transmitted vibration (HTV) and may experience tingling and numbness resulting in hand-arm vibration syndrome (HAVS). The vibrotactile threshold in fingertips is affected not only by vibration waves characterized by the frequency, displacement, velocity, and acceleration but also by environmental conditions that include the environmental temperature, humidity, temperature of tool grips, and perspiration in palms. The effects of the environmental conditions on the vibrotactile threshold in fingertips are known as temporary threshold shifts (TTS) of fingertip vibratory sensation. Our final goal in this study is to construct a computational hand-arm system that can successively predict the biodynamic response of the human hand-arm system under arbitrary environmental conditions. As the first report of this study, this paper presents the general concept of fabrication of a finite element model for the computational hand-arm system that couples the heat transfer equation in bio-tissues with the wave propagation equation.

1. Introduction

A prolonged occupational exposure to hand-transmitted vibration (HTV), arising from the operation of hand-held power tools, has been associated with the development of vascular, sensorineural and musculoskeletal disorders in tool-users' hand-arm systems, called hand-arm vibration syndrome (HAVS). (Bovenzi 1998; Pelmear and Leong 2000) Epidemiological studies have shown that mechanical vibration can induce the symptom of vibration white finger (VWF) disease, which is usually initiated at the tips of the index and middle fingers of the workers occupationally exposed to HTV. Since the recognition of HAVS in early 20th century, many challenges have been carried out with

Presented at the 14th Japan Conference on Human Responses to Vibration, Held in T.M.U., Hachioji, Tokyo, Japan, Aug 2nd to 4th, 2006.