3. Research object

We tested 13 pieces of wire cup brush of 2 types (the standard type of Diameter $\phi 65 \sim \phi 76$, crimped wire<Fig.3> and the knot type whose wire be twisted to decrease the possibility of scattering of wire fatigue<Fig.4>) of 7 companies for the experiment (Table 4). As these two types are often used in the workplace, we used these brushes to gather the vibration exposure data of handheld tools for the experiment.

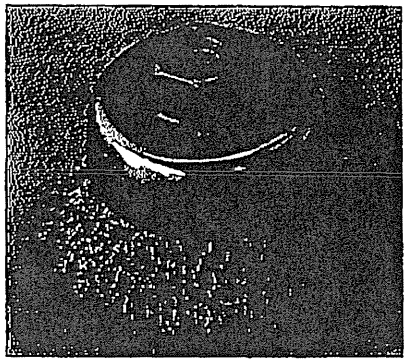


Fig.3 Crimped wire

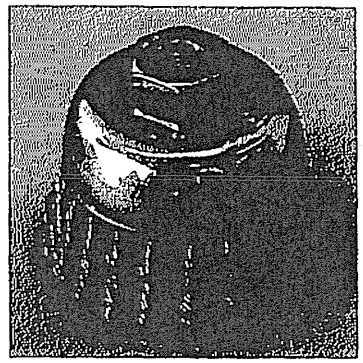


Fig.4 Knot wire

(crimped wire type)			
W1	30790	diameter76	stainless wire Φ0.36
W2	CW75-C25	diameter75	braided brass coated crimped wire Φ0.27
W3	06747194	diameter75	steel wireΦ0.3
W4	C-20	diameter75	steel wire Φ0.25
W5	CN-4	diameter75	braided brass coated crimped wire Φ0.27
[Kont wire type]			
W6	94729	diameter70	steel wireΦ0.35
W7	Hurricane twist	diameter70	steel wireΦ0.35
W8	BeeRex	diameter70	steel wireΦ0.35
W9	608131	diameter65	steel wireΦ0.35
W10	BS65M10-035	diameter65	steel wireΦ0.35
W11	09151895	diameter65	steel wire Φ0.35
W12	CN-22	diameter75	steel wireΦ0.5
W13	TN-075K4	diameter75	steel wireΦ0.35

Table 1

4. Measurement method

4.1 Vibration measurement

This device as below was used to make the measurement of the hand-transmitted vibration exposure from handles on handheld power tools based on ISO5349-1, ISO5394-2 (JIS B 7761-2, JIS B 7761-3).

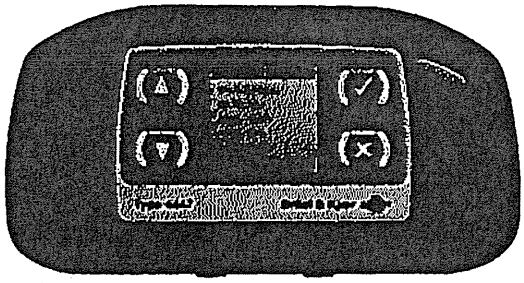


Fig. 5 HAVS –Hand Arm Vibration and Whole Body Vibration Meter Type 4447

Each wire cup brush was attached to a grinder and the effective acceleration of frequency-weighted vibration for the handle position along three axes (the x, y, and x axis) for one worker was measured on the basis of the ISO 5349-2 method for on-site measurement. The total value from these three axes was then obtained. Each measurement was taken within 30 seconds.

Total Effective Acceleration of Frequency-Weighted Vibration for the Three Axes: $a_{hv} = \sqrt{a_{wx}^2 + a_{wy}^2 + a_{wz}^2}$

Here, awx, awy, and awz are the effective acceleration of frequency-weighted vibration values for the x, y, and z axial directions.

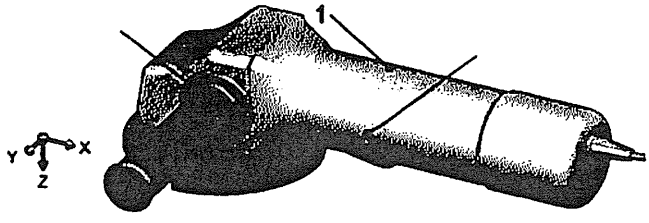


Fig.6 The measurement points on a grinder

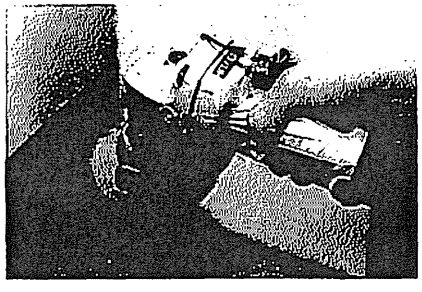


Fig.7 During the measurement

4.2 Balance measurement

A dynamic balancing machine was used to measure the balance values of the wire cup brushes.

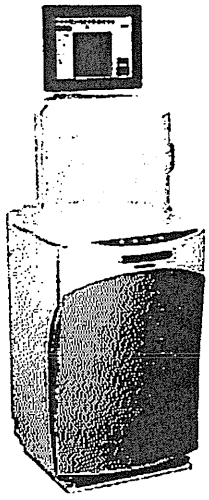


Fig.8 dynamic balancing machine V-10K

An M10 adapter was produced to the same specifications as the grinder in order to measure the balance values of the wire cup brushes within this machine. The adapter was fixed to the wire cup brush and spun at 1100 rpm. If the brush displaced from the rotor's center by the centrifugal force of rotation, the data shows the amount of vibration. Before the measurement, each cup brushes were set to the perfect balanced electrically and the measurement time was set to 10 seconds.

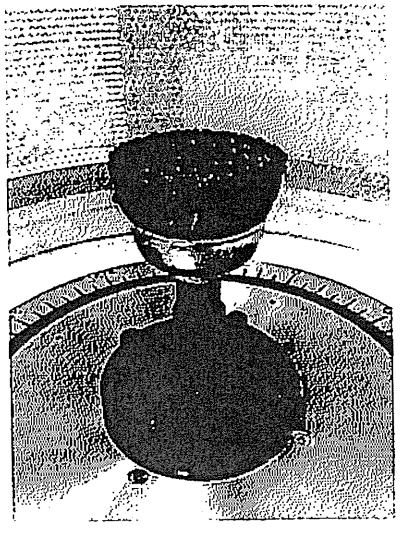


Fig.9 Measurement unit at the measurement device

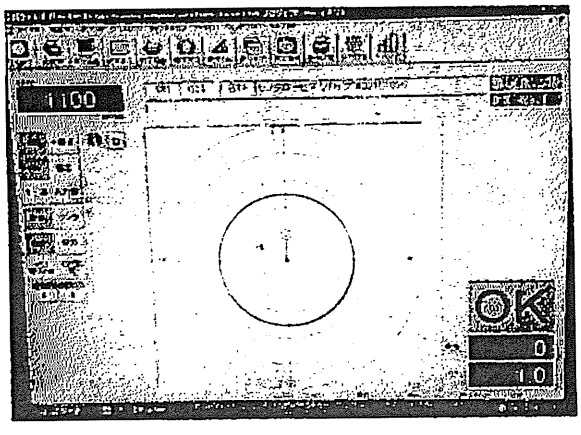


Fig.10 Measurement result screen

5. Results & Discussions

Table 2 shows a list of the vibration and balance levels for each wire cup brush. The brushes with the highest and lowest vibration and balance values in this table were investigated. The brush with the highest vibration value was W2 with an ahv of 6.97. The brush with the highest balance value was also W2, at 3.4 g. The brush with the lowest vibration value was W6 with an ahv of 2.92. The brush with the lowest balance value was also W6, at 0.7 g.

We can see the relationship between the vibration value and the balance value.

Next, Table 3 is the dispersion diagram of vibration and balance levels. A few of them exceed the daily vibration exposure limit A (8) of 5.0 m/s2. In order not to exceed the daily vibration exposure limit A (8) of 5.0 m/s2, the balance value should be less than 2.3 g or less, it could be linked to prevent the Hand-Arm Vibration Syndrome.

			n=5	ahv	balance
W1	30790	diameter76	stainless wireΦ0.36	5.52	1.1
W2	CW75-C25	diameter75	braided brass coated crimped wireΦ0.27	**6.94**	**3.4**
W3	06747194	diameter75	steel wireΦ0.3	6.2	2.1
W4	C-20	diameter75	steel wireΦ0.25	3.97	1.2
W5	CN-4	diameter75	braided brass coated crimpedΦ0.27	5.34	3.3
W6	94729	diameter70	steel wireΦ0.35	**2.92**	**0.7**
W7	Hurricane twist	diameter70	steel wireΦ0.35	4.82	1.1
W8	BeeRex	diameter70	steel wireΦ0.35	4.62	1.5
W9	608131	diameter65	steel wireΦ0.35	3.2	1.8
W10	BS65M10-035	diameter65	steel wireΦ0.35	3.64	1.6
W11	09151895	diameter65	steel wireΦ0.35	4.06	2.5
W12	CN-22	diameter75	steel wireΦ0.5	4.60	1.9
W13	TN-075K4	diameter75	steel wireΦ0.35	4.56	2.2

Table 2 Result of the vibration value and balance value

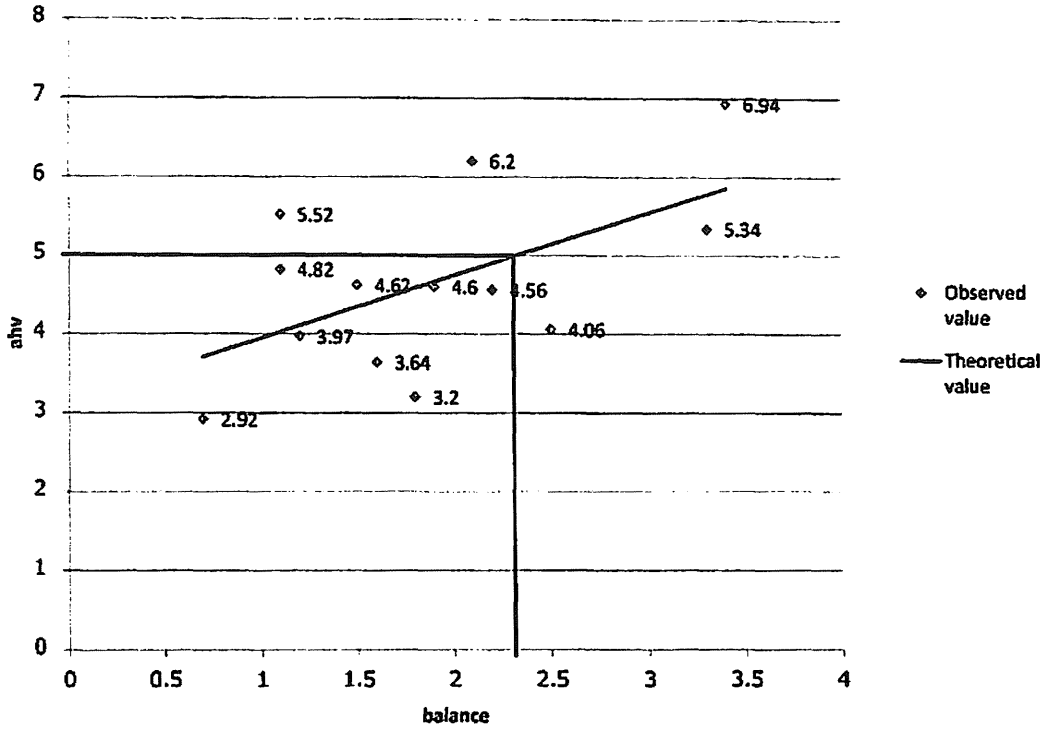


Table 3 Distribution map of the vibration value and balance value

6. Conclusions

By investigating the relationship between the vibration and balance value of wire cup brush mounted on handheld power tools, we make the conclusion as follows:

(1) The vibration value of wire cup brushes differs from manufacturer to manufacturer.

(2) There is a clear relationship between vibration values and balance values.

(3) Not exceeding the daily vibration exposure limit A (8) within 5.0 m/s2, the balance value should be controlled within 2.3 g or less.

References

"The Situation and Issues of Vibrating Tools" ("Safety and Health" February 2011 Issue, Japan Industrial Safety and Health Association)

The 20th Japan Conference on Human Response to Vibration (JCHRV2012)
Kinki University, Osaka, Japan
September 4 - 6, 2012

Development of hand-arm vibration measurement device

Tadayoshi Mae[1)*] Keisuke Fujimoto[2)] Shigenobu Yoshida[1)]
Kazuya Shimizu[2)] Kazuhisa Miyashita[3)] Setsuo Maeda[4)]

1) Taikoh Corporation
2202-21 Shoda-cho Tsu-shi Mie 514-1255, Japan
mae_tadayoshi@taikoh-mie.co.jp
2) DEED CO., LTD
M' Plaza-307 4-38 Tennouden, Jyoutou-ku Osaka 536-0012, Japan
3) Department of Hygiene, School of Medicine, Wakayama Medical University
811-1, Kimiidera, Wakayama, 641-8509, Japan
4) Department of Applied Sociology, Faculty of Applied Sociology, Kinki University
3-4-1 Kowakae, Higashiosaka 577-8502, Japan

Abstract

About the indicator concerning vibration released new data by the Ministry of Health, Labour and Welfare on July 10, 2009.
Three axis synthetic value of the RMS value is calculated, and the measurement device of the hand-transmitted vibration corresponding to the daily amount A(8) of the vibration exposure has been developed.

(1) Device spread to tool manager
The device by which the measurement of three axis synthetic value of the RMS value that is an important duty of "Person in charge of the vibration tool management" becomes simple has been developed.

(2) Device spread to worker
The general-purpose type measurement device is light, compact, efficient the price is very reasonable.

1. Introduction

The product development and the evaluation done based on the plan project of "Hand arm vibration measurement device" that was announced the 18th at the Japan vibration society held in August, 2010 is described below.

1) Product development according to vibration tool user.

"For the person in charge of vibration tool management" and "Workers who use vibration tools"

Two models of the measurement device have been plan to develop one for "For the person in charge of the vibration tool management" and one for "Workers who use vibration tools". And, the development of the device "For the person in charge of the vibration tool management" has been executed.

① An initial, experimental evaluation "For the person in charge of the vibration tool management" has been completed. In addition, an experimental evaluation has been executed for the mass-produced device. The device product reduced the worker's daily physical operation. And, it is easy to use it by the simpleness of operation. It is easy to see the LCD screen display vividly. And, the concept of the product has been confirmed.

② " Workers who use vibration tools " is developed based on "For the person in charge of the vibration tool management". In addition, the development research to reduce the size and cost of the device has been executed.

2. Product specification

As for this product, development based on the standard of JIS B7761-1, 2(2004), and ISO5349-1 ,2 was done. Therefore, the following item becomes important in hardware.

1) Pick-up for vibration detection (3 axis acceleration sensor)

At present, In the marketed measurement device, in the cost of the entire product, the ratio of pick-up is high. Because the price is very high, MEMS that is general-purpose parts is used to achieve a low price. And, the performance of pick-up is maintained and composes of a low-priced sensor.

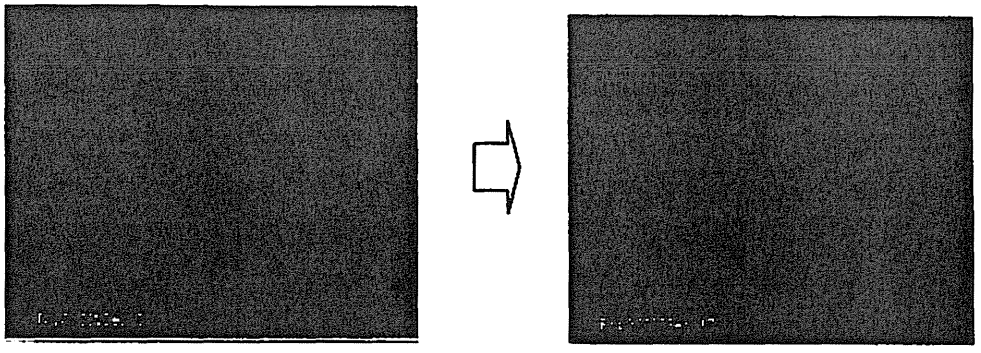
2) FPGA is adopted for core IC used for the main body of the measurement device.

When the product of "For the person in charge of the vibration tool management" and "Workers who use vibration tools" is made, the miniaturization becomes an important development item. Therefore, the development for the miniaturization became possible because it had adopted FPGA. Especially, the product for which more miniaturizations are necessary is "Workers who use vibration tools". A necessary part of FPGA is made ASIC. And, becomes possible because it is produced by COB.

3) About the development of the main body of the product

In the stage before the first prototype production, it is necessary to confirm the operation logic plan from which "Three axis synthetic value of the frequency correction acceleration

effect value" is requested with the measurement device. As the technique for confirming validity, the frequency correction program (Fig1) was made using a WindowsPC, and evaluated.



Before corrects　　After corrects

Fig 1. Result of inputting sine wave of 100Hz to correction program

Table 1. Frequency correction program evaluation

平均加速度(加速度実効値)			
入力値	90.454	補正値	0.1603
加速度実効値(補正値)	14.499	dB値	-15.902

Moreover, the correction was calculated from all frequency that was the demand of JIS, and validity was able to be confirmed(Table 1). And the plan of the first prototype and the prototype before mass production has been executed.

4) About the performance of FPGA and the process of the function confirmation

The following substrate had been made before the first prototype was made. Expansion substrate that can be connected with evaluation substrate that FPGA enters. The measurement device to a necessary function and logic were confirmed, and the performance of FPGA was evaluated. The important confirmation item is the method of the accuracy and the data handling to the frequency correction operation block composed in FPGA signal processing circuit (DSP). The result of the frequency correction operation done to the input signal of the digitalized sensor has the number of signal bits (number of operation digits) that exist in DSP, there is a possibility that accuracy that is necessary cannot be guaranteed. Simulation deliberate on MATLAB was done and the number of signal bits was confirmed. After it had been confirmed in this former process, the first prototype production that became a measurement device was executed. The composition of the device contains the battery (lithium-ion battery) and the circumference circuit.[2]

As for the specification, it's the first prototype that the specification of various functions of the product of another company contains. Moreover, the verification was executed by those functions.

5) Development of pick-up for vibration detection

The specifications of the manufacturing manufacturers of the MEMS acceleration sensor were confirmed. As a result, MEMS that was able to cover 8-1000Hz needed in the hand arm vibration measurement device in the official frequency range was selected. Pick-up executed the evaluation of one kind. (16G) (Fig 2)

: Shape and specification of pick-up

・Acceleration ±16G ・Frequency 0-1500Hz ・Size 25mm square

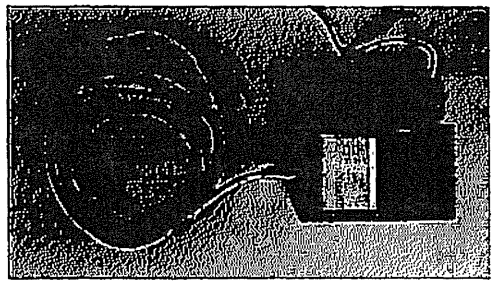


Fig 2. First prototype

6) About the evaluation of first prototype

The prototype and pick-up executed the vibration exciter test and the test with the vibration tool. The MEMS (pick-up) was able to be used from the evaluation result as pick-up for the hand arm vibration measurement.(Table 2).

Table 2. Sensor comparison verification with the other companies product

Sensor comparison verification with product of another company

Basic frequency: 159.2Hz Basic acceleration value: 10m/s2(RMS)

(Tolerance of each axis 1.11~0.899 1.00±0.11)

No.	Equipment name	x axis	y axis	z axis	RMS
1	B&K 4447	0.9926	0.9954	0.9962	1.723
2	PCB HVM100	1.03	0.991	1.01	1.750
3	01-dB MAESTRO	1.10	1.02	1.01	1.808
4	RION VM-54	1.03	1.04	1.0413	1.796
5	HVLab	0.996	0.995	1.00	1.727
6	B&K PULSE	1.01	0.998	1.00	1.737
7	**First prototype**	1.02	0.999	0.925	1.701

However, the verification that had become an overload (Fig 3) [1] concerning the sensor of 16G by the vibration test on the vibration tool was confirmed. Therefore, the evaluation by MEMS of other cooking stoves is executed.

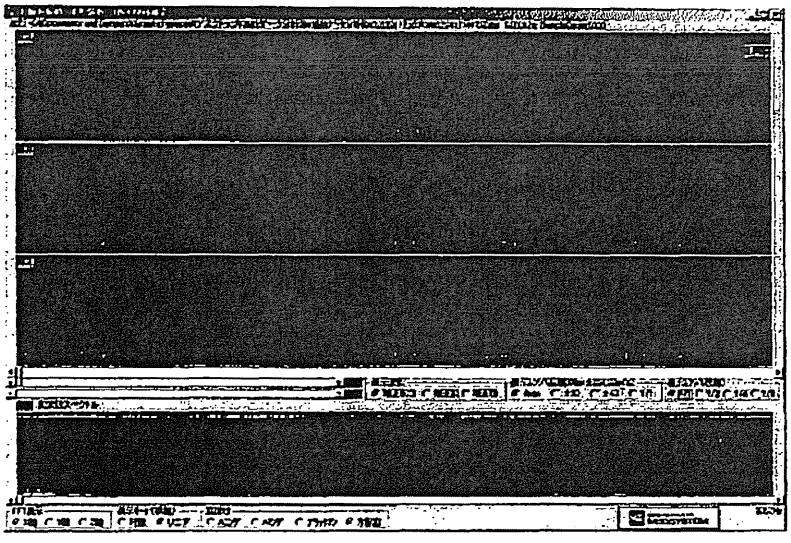


Fig 3. Overload verification by impact

The main body of the measurement device need raise slice (operation element) rate of FPGA along with the cooking stove kind of MEMS. In the advantage of the FPGA function, the confirmation of the design specification by a hard rearrangement was verified.

7) About evaluation of Prototype before mass-product

Final specification (Table 3) was confirmed from the verification result of the prototype. (Fig 4) (Fig 5)

The measurement device was decided the miniaturization of the size of the sensor.

And, the performance evaluation is advanced.

Fig 4. Prototype before mass-product

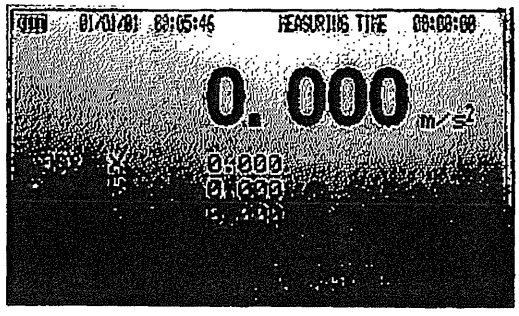


Fig 5. Prototype before mass-product Measurement display

·Table 3 Prototype before mass-product specification

Display	2.7 inches on liquid crystal screen, 400x240dot Black and white
Power supply	AC100V adaptor, Equipped with battery, Possible to use for continuousness eight hours
Range of use temperature humidity	- 10℃~+50℃ and 90%RH or less
Size and mass	36(H) × 166(W) × 116(D)mm、230kg(Only the main body)

It is easy to use because of an easy operation. It's safe to use and light in weight (230g).

It isn't a burden "For the person in charge of the tool management".

The majority can be used only on the measurement screen. Moreover, the improvements of

parts, circuits, hard technologies, and software, etc. were done at the continuous use time of the battery. And, the specification that enabled energizing of eight hours corresponding to A(8) was composed. Energizing of eight hours is an evaluated situation.

Table 4 MEMS sensor specification

Sensor model	Range of detection	Bandwidth
TVM-01	16G	1600Hz
TVM-02	35G	400Hz
TVM-03	50G	400Hz
TVM-04	70G	400Hz
TVM-05	120G	400Hz
TVM-06	200G	1200Hz
TVM-07	250G	400Hz

Pick-up for the vibration detection selected seven kinds (Table 4) with different specification. About three kinds of selections are planned from among these.

The size of the sensor is 15mm square. The miniaturization became possible.

3. Results and Conclusions

3-1. About first Prototype

① Main body of product (Measurement operation part)

The measuring instrument evaluation in JIS standard demand was completed. And, a basic composition to the prototype before mass-product was established.

② MEMS 3 axis sensor

The specification of the demand of the standard that related to JIS standard was able to be confirmed from the evaluation of an experimental sensor by 16G specification. And, several kinds of the evaluation of the sensor according to various specifications are executed in the prototype before mass-product applied for practical use.

3-2. About prototype before mass-product

① Main body of product (Measurement operation part)

- About the prototype before mass-product

  In the demand of JIS standard, the evaluation is planned.

  : Performance demand evaluation examination

  : Environmental performance examination as measurement device

- Problem examination item

  The preservation of acquired data and the use of data, etc. are examined by the measurement. It concerns the business of "For the person in charge of the vibration tool management". An effective function does assume a standard specification or

examines whether to assume the option. And, development is planned.

② MEMS 3 axis sensor

The range of minimum use is selected from seven kinds of MEMS sensors as an evaluation verification.

3-1. About the small measurement machine of " Workers who use vibration tools "

A technical problem advanced to "Workers who use vibration tools" is excerpted from the evaluation that is the prototype before mass-product for " For the person in charge of vibration tool management ". Especially, a necessary part of FPGA is made ASIC.

And, the product that becomes a miniaturization that the worker can easily carry by the work by COB is designed.

4. References

[1] Chapter of Nishihara accountant 「Introduction to sensing」 (ohm company), 2007.

[2] Written by Masanori Kikuchi 「Electronic device」 (Japanese business publisher), 2005.

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Calculation System for A(8) using Email system

Atsushi Yoshioka[1],Setsuo Maeda[2], Kazuhisa Miyashita[1]
[1]Wakayama Medical University
811-1 Kimiidera
Wakayama, 641-8509, Japan

[2]Department of Applied Sociology, Faculty of Applied Sociology, Kinki University
3-4-1 Kowakae,
Higashiosaka 577-8502, Japan

Abstract

This paper is an introduction of daily exposure value calculation system by using email system.

The Ministry of Health, Labour and Welfare has issued New Japanese Guidelines for Preventing Hand-Arm Vibration Syndrome. Then we are able to know how much vibration total value of frequency-weighted r.m.s. acceleration, (a_{hv}) is emitted from vibration tools.

The daily exposure value calculation tools are provided such as a spread sheet and a nomogram from MHLW. This email system was developed for one of calculation tools to know daily exposure value at work place by using email such as a cell phone whether workers can know if his or her work fits with the guideline or not.

1. Introduction

The A(8) calculation system has been developed to be used at work place. The workers who are going to use vibration tools, their employers are required to do risk assessment how much risks exist their plan by calculating dairy exposure value.

After New Japanese Guidelines for Preventing Hand-Arm Vibration Syndrome [1] were issued by the Ministry of Health, Labour and Welfare , the manufacturers provide the a_{hv} by their web site, catalogs and manuals. So, workers or management officers of the occupational safety and health have been able to know daily exposure value A(8) by using provided a_{hv} and their working time. Some of calculation tools are well-known already such as spread sheet [2] provided by the Ministry of Health, Labour and Welfare, a nomogram and so on. However, in case of workers or management officers of the occupational safety and health, they have to change the working plan at working place where is no PC and no nomogram or they would like to use 7 or more vibration tools. And also, they need the knowledge about A(8) calculation formula or skill of calculation by using a nomogram at the working site But, it's very difficult thing for them. Therefore, they need the simple calculation system at the worksite to calculate the A(8) value.

So, in this paper, the calculation system by using email system was developed to be not only one of convenient tools for dairy work but also, complementary system to calculate because it assumes that almost of workers or employers or management officers of the occupational safety and health have a cell phone and they have a skill of using cell-phone's email.

2. Environment and outline of work follow of system.

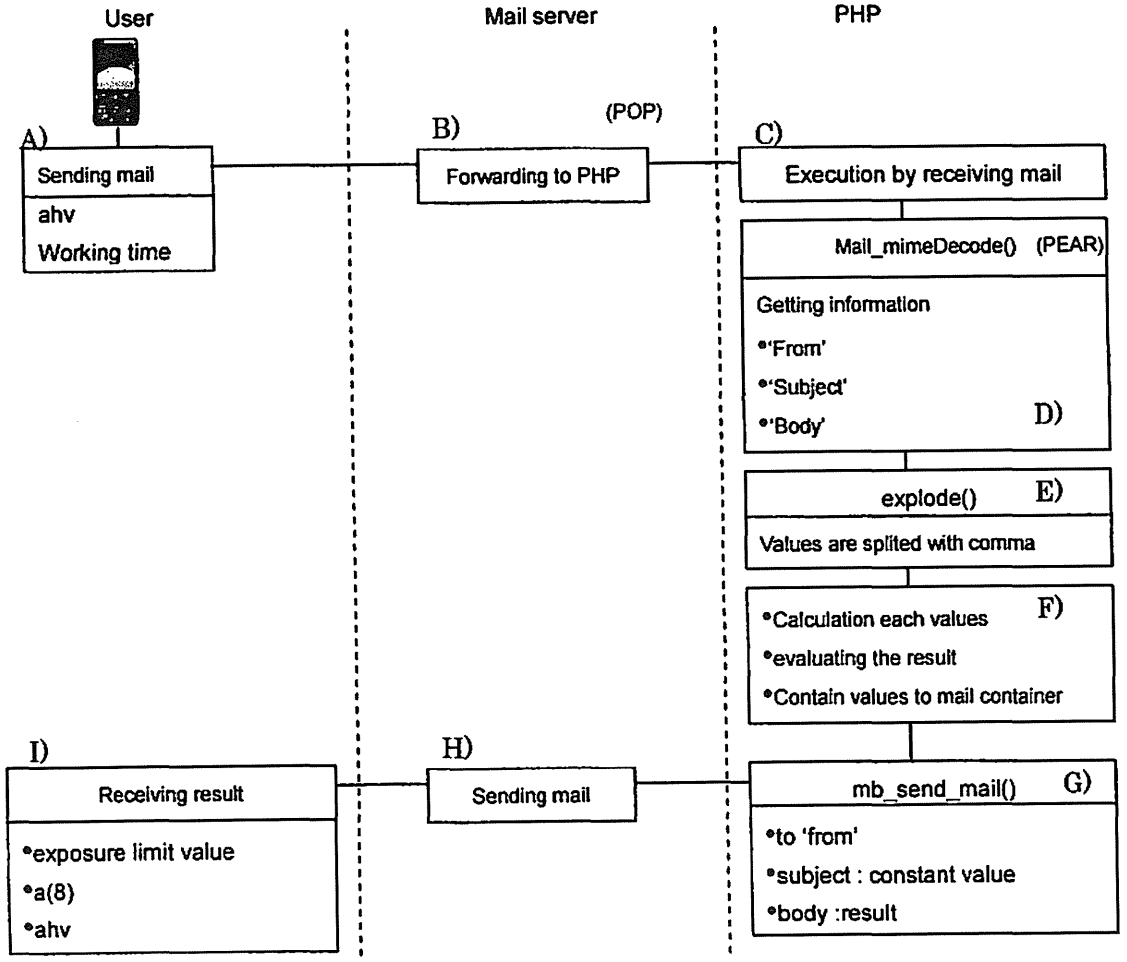
2.1 Environment

This system is built under the environment following;

- Rental Server: Xserver
- Operation System: Linux 1.6.18
- Mail server: Sendmail
- Server program: PHP Version 5.3.3[3]
- PHP Extension and Application Repository (PEAR)[4]
  =>Mail_mimeDecode-1.5.5

2.2 Work flow and detail

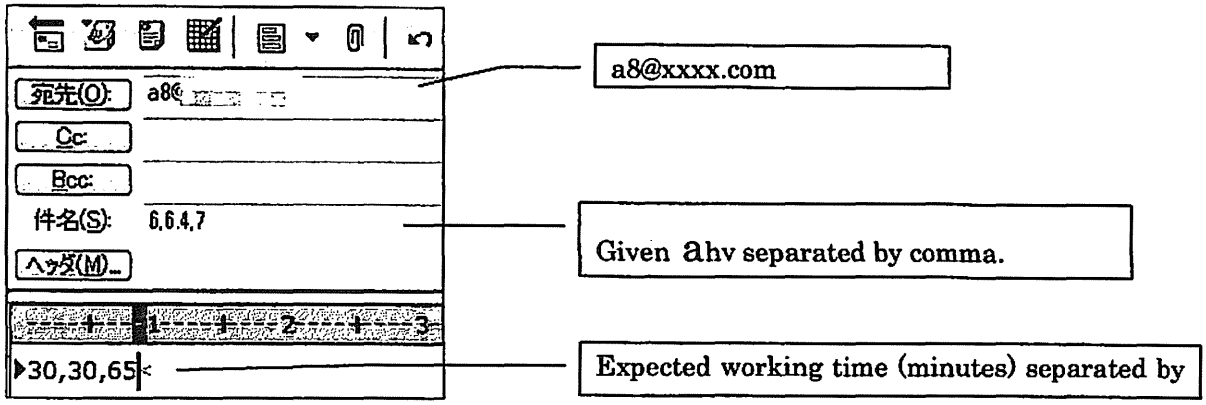
The work flow is shown as Fig.1



<Fig. 1 Work flow>

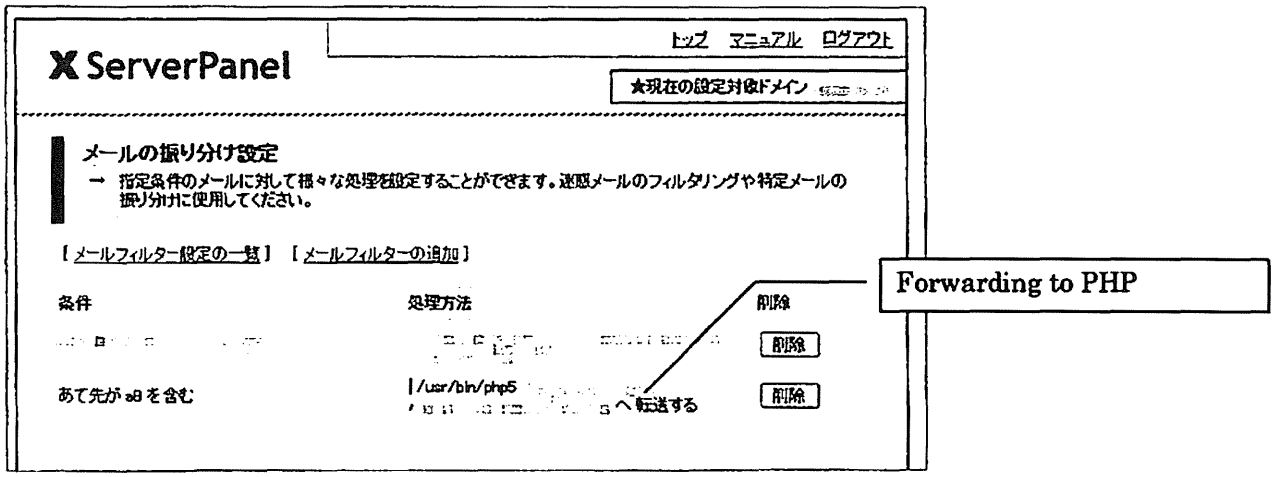
Detail of work flow is shown by flowing;

A) Users send a mail which is contained ahv and working time they expected as Fig.2.



<Fig.2 sending mail>

B) Mail distribution function in the mail server is set to forward to PHP program as Fig.3



<Fig.3 forwarding setting of server>

C) PHP program is run by receiving the mail.

D) "Mail_mimeDecode()" PEAR module takes "from", "subject" and "body" from the mail.

```
include ( '/home/xxxxx/xxxxxx/xxxxx/PEAR/Mail/mimeDecode.php');//include mimeDecode
  // Taking mail information
  $params['include_bodies'] = true;
  $params['decode_bodies']  = true;
  $params['decode_headers'] = true;
  $params['input'] = file_get_contents("php://stdin");
  $params['crlf'] = "¥r¥n";
  $structure = Mail_mimeDecode::decode($params);
  //Getting mail sender
  $mail = $structure->headers['from'];
  $mail = addslashes($mail);
  $mail = str_replace("'","",$mail);

  // getting subject
  $subject = $structure->headers['subject'];
  $body = $structure->body;
```

<Fig.4 example of taking information by using PEAR/Mail/mimeDecode>

E) "explode()" function splits the each number of ahv and working time as Fig.5

```
$ahv = explode(",", $subject);// split by comma and making the array.
$jikan = explode(",", $body);//split part by comma and making the array
```

<Fig.5 split part for each vibration tools>

F) A(8), exposure limit vales are calculated in this block. And the calculated numbers are evaluated. After that result (A(8), exposure limit value and result of evaluation) are contained to variable.

```
//calculation and contain to message
$gosei_ahv = pow($ahv[0],2)*$jikan[0];
$gosei_jikan = $jikan[0];
for ($i=1;$i<count($ahv);$i++){
$gosei_ahv += pow($ahv[$i],2)*$jikan[$i];
$gosei_jikan +=$jikan[$i];
}
$gosei_ahv = sqrt($gosei_ahv/$gosei_jikan);//ahv calclation
$gosei_ahvr = round($gosei_ahv,2);
$a8 = round($gosei_ahv * sqrt($gosei_jikan/480),2);//A(8)  calculation
```

① ②

<Fig 6 ahv and A(8) calculation [5]>

$ahv is arrayed variable, so ,① in the Fig 6. is calculation part of ahv and whole working time of all vibration tools by loop . ② is calculation formula of A(8) by minutes. It is equal to :

$$A(8) = ahv \times \sqrt{(T/480)} \quad [5]$$

```
//Loading message
$n = 0;
foreach ($ahv as $value) {
    $ji = str_replace("¥n", "", $jikan[$n]);
    $genkai = round(12000/pow($value,2),1);// calculating exposure limit value
    $genkaih = round($genkai/60,1);
    $kobetsua8 = round($value*sqrt($ji/480),2);//calculationg A(8) for each tools
    $message .= "$value m/sec^2 の工具を $ji 分使用: 日振動ばく露量
                A(8) $kobetsua8 m/sec^2 ¥n";
    $message .= "この工具のばく露限界時間: $genkai 分( $genkaih 時間)¥n¥n";
    $n += 1;
}                                                                    ③
$message .= "¥n¥n";
$message .= "全工具の 3 軸合成値 :  $gosei_ahvr m/sec^2¥n";
$message .= "計画上の全作業時間: $gosei_jikan 分¥n";
$message .= "日振動ばく露量 A(8):  $a8 m/sec^2¥n¥n";                  ④

// evaluation of result
if ( $a8 <= 2.5 ){
   $message .="日振動ばく露対策値を超えません。¥n";
   if ( $gosei_jikan > 120 ){
        $message .= "当面の間は、作業時間を 2 時間以内とする必要があります。¥n";
        }
} elseif ( $a8 <= 5 ){
        $message .= "「日振動ばく露限界値」を超えない場合であっても、
        「日振動ばく露対策値」を超える場合は、振動ばく露時間の抑制、
        低振動の振動工具の選定等に努める必要があります。¥n";
    if ( $gosei_jikan > 120 ){
        $message .= "当面の間は、作業時間を 2 時間以内と
        する必要があります。¥n";
        }
} else {
   $message .= "日振動ばく露量 A(8)が、「日振動ばく露限界値」
   を超えることがないよう振動ばく露時間の抑制、低振動の
    振動工具の選定等を行う必要があります。¥n";
    if ( $gosei_jikan > 120 ){
        $message .= "当面の間は、作業時間を 2 時間以内とする必要があります。¥n";
        }
}                                                                    ⑤
```

<Fig.7 Loading message and evaluation of result [2]>

③ is calculation part of A(8) and exposure limit time for each tools and also the part loads the result to the message variable.

④ is message loader of the result for ① and ② in Fig.6.

⑤ is evaluation part by the calculated results. This part is one of the most important parts for user because worker is able to get the information corresponding to his or her working plan.

The given information is corresponding to spread sheet[3] which provided by Health, Labour and Welfare Ministry.

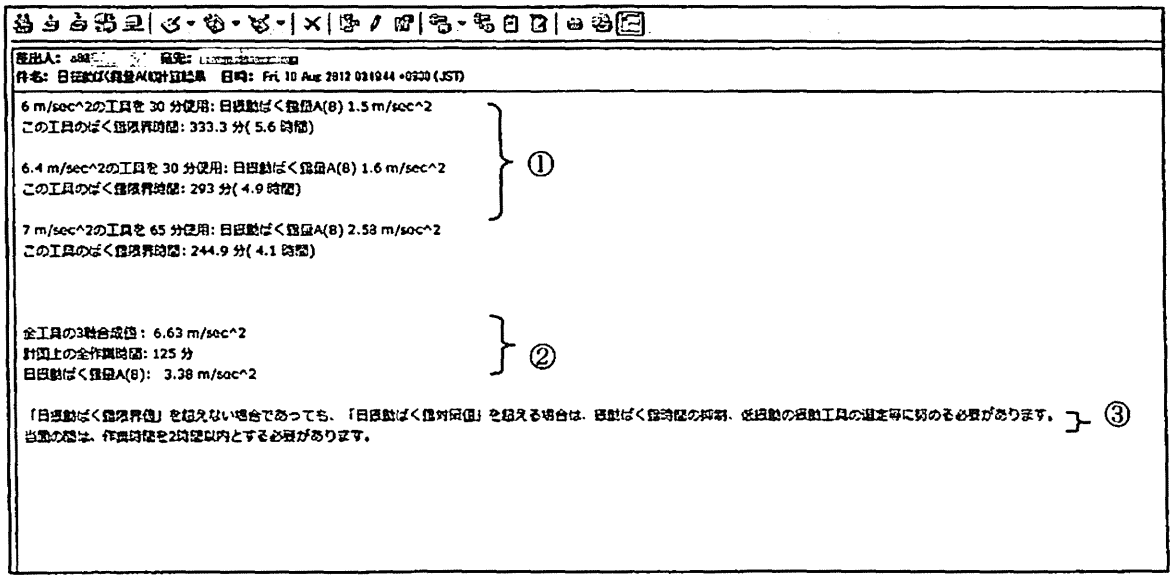
G) mb_send_mail() pass the send mail.

```
mb_send_mail($mail , "日振動ばく露量 A(8)計算結果", $message , $header );
```

<Fig.8 Pass the return message to send mail on mail server>

H) Mail server sends back to worker.

I) Worker receives the message from system. The example of message is shown in Fig.9.



<Fig.9 example of receiving message>

This massage is the returned massage that the worker sent "6,6.4,7" to the subject (ahv) and "30,30,65" to the body as corresponding to Fig.1.

① Fig.9 is result of calculation A(8) and exposure limit value for each vibration tool.

In this case:

i) A(8) = 1.5 m/sec^2 , exposure limit time = 333.3 minutes by calculating with **6msec^2** and **30 minutes**.

ii) A(8) = 1.6m/sec^2 , exposure limit time = 293 minutes by calculating with **6.4msec^2** and **30 minutes**.

iii) A(8) = 2.58m/sec^2 , exposure limit time = 293 minutes by calculating with **7msec^2** and **65 minutes**.

② This part is result of calculation with when vibration tools.

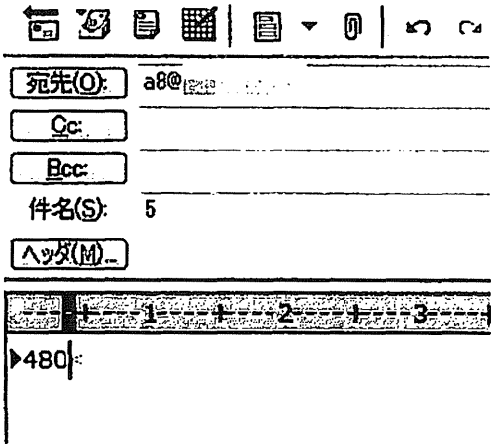
In this case:

a_{hv} = 6.63 m/sec^2 ,working time 125 minus, A(8) = 3.38m/sec^2

③ This part gives a hint which is generated by result calculation. The statement of hint is same as the spread sheet[3] which is provided by Health, Labour and Welfare Ministry on their web site.

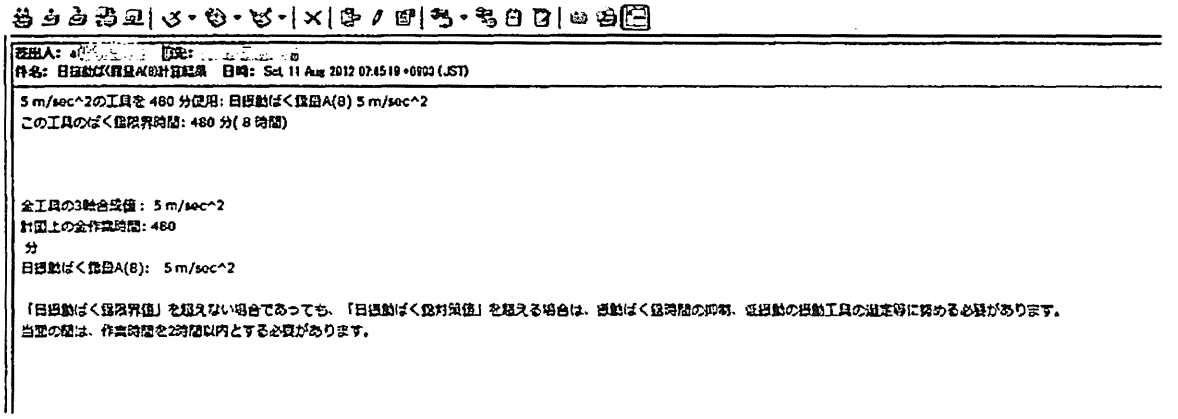
3. Verification.

3.1 When use number a_{hv}=5m/sec^2, and 480 minutes as Fig.10.



<Fig 10. 5m/sec^2 ,480 minutes>

Returns result A(8) = 5m/sec^2 , Exposure Limit time is 480 minutes, as Fig11.



<Fig.11 result>

A(8) = 5.0 x $\sqrt{}$(480/480) = 5.0 [m/sec^2]

T_L = 12000 / 5.0^2 = 480 [minutes]