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

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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^{TM} system (B&K, 3109) and it is denoted at the one-third octave band center frequencies.

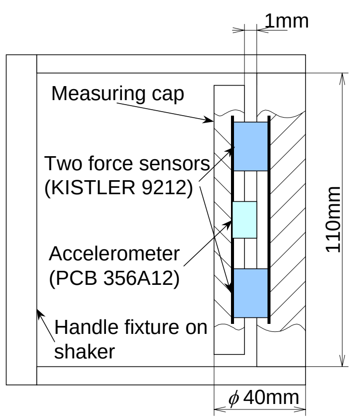

Fig. 1 Instrumented handle of the system

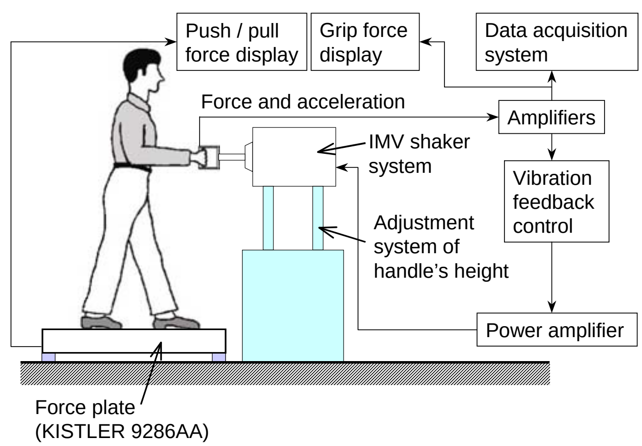

Fig. 2 Measurement system at the NIIH

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 AM and true values are less than 3%. Since the resonant frequency is higher enough than frequency range of measurement (12.5 – 1,000 Hz), the assumptions seem to hold in the frequency range of measurement. The calibrations of the measuring cap's mass are shown in Fig. 3. The measured pieces of mass generally agree with the true mass value. The measured mass values of over 10g are bigger than the true mass value in the high frequency range (>600Hz).

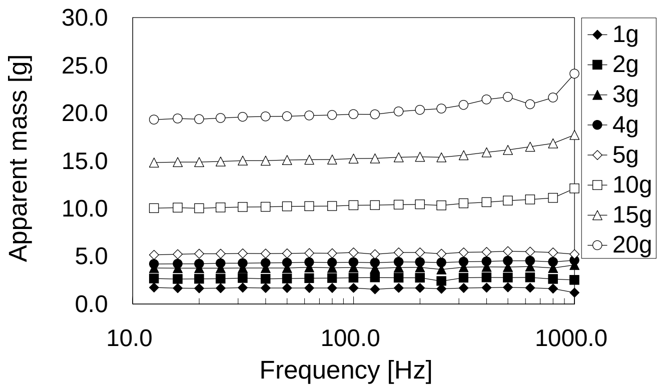

Fig. 3 Mass compensation results

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.

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References

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