INSTRUMENTED HANDLES FOR STUDYING HAND-TRANSMITTED VIBRATION EXPOSURE

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Introduction

Instrumented handles or dynamometers are widely used to measure hand forces and/or the biodynamic response of hand-arm system. To study hand-transmitted vibration exposure, six generations of instrument handles were constructed or initially developed by researchers in ECTB/HELD/NIOSH. This presentation provided a summary of these handles. Their basic characteristics, limitations, and usefulness are described, which may help their appropriate applications and further improvements.

Six Designs of Instrumented Handles

Handle 1: The conceptual design is recommended in ISO 10819 (1996)[1] for glove test. The grip force is measured by detecting bending strains on a measuring beam in the handle. A special handle fixture was designed to connect the handle to a shaker. Except the screws, the handle and fixture were made from aluminum.

Handle 2: The design is based on the principle of shear strain measurement.[2-3] Both grip and push forces can be measured simultaneously using this handle. This handle was directly designed for a simulated vibrating tool.

Handle 3: This design is basically composed of a handle base, a measuring cap, and two charge-based sensors (Kistler 9212) sandwiched between the base and cap. The handle was also made from aluminum. The fixture for Handle 1 was also used with this handle. This generation of handle has three different handle diameters (30, 40, and 50mm).[4]

Handle 4: This design is an improvement from Handle 3. The handle fixture was totally redesigned and it was much stiffer than the previous one. The aluminum measuring cap was replaced with a magnesium cap.

Handle 5: The basic structure of this handle is the same as that for Handle 3. However, the piezoelectric sensors were replaced with two strain gage based sensors (Interface SML-50).

Handle 6: This handle includes two measuring caps, four piezoelectric sensors, and a handle centre base. The handle fixture was the same as that with Handle 4.

Methods for Handle Examinations

The static and dynamic characterizations were performed using the methods reported by Dong et al.[5-6]

Results and Discussion

Handle 1: The static force measurement depended on the hand grip location on the handle. Its natural frequency was less than 200 Hz.[5,6] Because the transmissibility of gloves may not vary significantly with the applied grip force, this handle may be acceptable for glove test. However, the force measurements with this handle may not be reliable.

Handle 2: The static force measured with this handle was insensitive to the hand acting location. However, when the handle was vibrating, the force signals could be totally distorted. For this reason, it was not used for vibration studies.

Handles 3 and 4: The static force measurements with these handles were independent of the hand grip location.[6] The resonant frequency of the early version was about 1,450 Hz and the latest was about 1,900 Hz. These handles have been extensively used for both static and biodynamic measurement up to 1,000 Hz.[4,6] The experimental data measured with the handle have been used to develop biodynamic models. A sample model, together with its parameters, is shown in Fig. 1. The modelling results agree excellently with the experimental data, as shown in Fig. 2. The natural frequencies (29 Hz and 208 Hz), the damping ratios (0.29 and 0.73), and the potential static deformations of the hand-arm system in the possible hand force range are also very reasonable. Without the reliable and accurate experimental data, it is impossible to establish such a model.

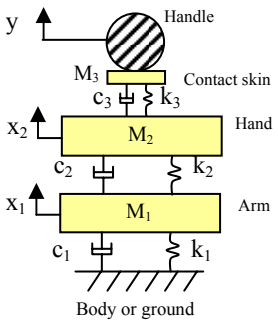

Fig. 1: A 3-DOF model (M_1=1.2320 kg; M_2=0.1774 kg; M_3=0.0338 kg; k_1 = 1.5 kN/m; k_2 = 48.5 kN/m; k_3=252.8 kN/m; c_1=54 N-s/m; c_2=104 N-s/m; c_3=231 N-s/m.)

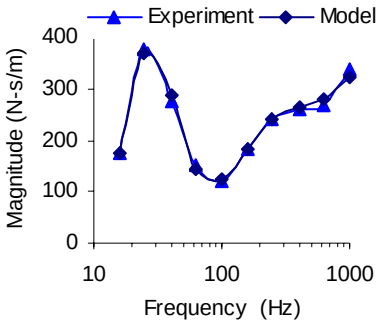

Fig. 2: Comparison of modeling and experimental impedance data (50 N grip-only) (r = 0.993).

Handle 5: Piezoelectric force sensor can have a significant zero-drift problem. The handle equipped with such a sensor may not be suitable for a long duration force measurement. The handle equipped with strain gauge sensors has no such a problem. However, because the sensor is not as stiff as the charge-based sensor, the handle resonance was at about 900 Hz. It has been used for studying hand force recall.[7]

Handle 6: Except for Handles 2 and 6, the other handles cannot simultaneously measure both grip and push forces. The push force is usually measured using a force plate in the experiment. The dynamic responses distributed on the fingers and palm can only be measured separately using Handles 3-5. Handle 6 was developed to overcome the deficiencies. Its natural frequency was about 1,450 Hz.

References

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