동력공구 작업시 수전달 진동에 관한 측정 불확도 분석

Investigation into the Uncertainty in Measurements and Evaluation of Hand-transmitted Vibration

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Key Words : Hand-transmitted vibration(수전달 진동), Measurement uncertainty(측정 불확도), Vibration exposure(진동 피폭)

ABSTRACT

현재 ISO 에서는 공구제조업체에서 해당 공구의 수전달 진동을 측정하여 제시하도록 하는 규격을 제정 중에 있으며, 이를 위해서는 공구에서 발생하는 진동과 영향을 평가하는 기술이 확보되어야 하며, 이 과정에서 측정 불확도 수준을 결정하는 것이 매우 중요하다고 하겠다. 본 연구에서는 동력 공구 작업시 작업자의 손으로 전달되는 진동을 측정하고 그 영향을 평가함에 있어서 발생할 수 있는 불확도를 분석하였다. 먼저, ISO 5349 규격을 적용함에 있어서 존재하는 불확도 인자들을 분류하고, 각 인자들이 어느 정도 수준의 불확도를 발생시키는지 시험을 통해서 확인하고 분석하였다.

1. Introduction

Accurate measurement and evaluation of hand-transmitted vibration from a power tool is an important issue for tool manufacturers, because they are obliged to develop low-hazard power tools for workers. The International Standard ISO 5349[1] dictates a systematic procedure for the measurement and evaluation of hand-transmitted vibration. However, the uncertainty in this measurement is too large for manufacturers to apply such data to the design and modification of power tools. There can be several sources of this uncertainty in such measurements; e.g., operator-dependent, power tool-dependent, and operational conditions (see Table 1).

For a manufacturer to characterize the exposure of a power tool's use to a given level of vibration, the relationship between these uncertainty factors and the measured vibration must be elucidated. In this study, we investigated the effect of several factors on the uncertainty in measurements.

2. Method

In this study, some of the factors in Table 1 were selected for examination, and their effect on the measured variation was quantitatively investigated.

Three tools from the same manufacturer were sampled at random in our experiments, and each of five of the same type of insert (disks or tips) was installed into each tool. Although each of the tools and inserts were of the same design and were made by the same production process, they differed from one to another, which can be a source of the variation in the measured vibration.

Table 1. The possible sources ofan uncertainty in a measurement

Tool	Operator	Operating condition	Instrumentations
Tool Grit/Tip/Insert Installation	Stature and weight Muscular strength	Posture Applying forces	Accelerometer Data processing device

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Three human subjects participated in our experiments, which were carried out as stated in ISO 5349. The subjects were asked to maintain their posture, and the applied force was kept as constant as possible. The applied force was monitored using an indirect method, where vibration energy was displayed in real time during the experiment using a three-axis accelerometer attached to the work piece at a specified point. The appropriate range of the applied force was predetermined to cover the range of real work operations. The engineering tolerance between the inner diameter of a grit disk and the outer diameter of the tool shaft leads to an eccentricity of the mass at the center of the disk. The degree of eccentricity varies with installation, and this is another source of uncertainty. In our study, the effect of this eccentricity was investigated by carrying out repeated assembly and disassembly of an insert.

Human exposure levels of hand-transmitted vibration were measured in 45 combinations of the three subjects using three tools of the same make, and five inserts of the same make for each of the three types of tool studied: a 7" and a 4" grinder, and a die grinder. Each measurement was performed following the procedure listed in ISO 5349. Data acquisition for each case was made over a period of five minutes involving five repeated one-minute measurements.

3. Results

Table 2 shows the variation in human exposure levels to hand-transmitted vibration, a_{hv}, for the selected factors. For example, the 7" grinder showed a variation of 13.7% for our subjects using the 15 tool and insert combinations. For the three types of tool, the effect of the variation among the tools, which was closely related to the quality of the product was the most dominant factor. Variations in the vibration according to subject varied from 11.7% to 13.7%, which seems reasonable, because the applied force was monitored and controlled during the measurement. Variations according to the insert are possibly caused by irregularities in the insert and/or installation. Variations in the measurements according to installation were investigated in a separate experiment.

4. Discussion

We have investigated the effect of several factors on the uncertainty in measurements of hand-transmitted vibration. Among the three major factors studied, the variation according to the tool used was the most dominant factor, even though this was limited. The variation according to subject showed a consistent value of 11.7% to 13.7% for the three types of tool studied. The variations according to insert had two causes: one was due to the irregularities between the inserts, and the other was due to the eccentricity of the rotation, which is currently under further investigation.

To compare human exposure levels to vibration in different tools, which is necessary for the selection of better tools, more research into the effect of the factors that influence the uncertainty should be carried out.

Table 2 Variations in human exposure levels of hand-transmitted vibration with different tools, inserts, and subjects.

	Factor		
	Subject	Tool	Insert
7" Grinder (plus grit grinding wheel) grinding stainless steel	13.7%	40.3%	14.7%
4" Grinder(plus grit grinding wheel) grinding stainless steel	11.7%	18.6%	9.5%
Die grinder (plus rotary cutter) grinding stainless steel	13.4%	18.9%	16.4%

Reference

(1) International Organization for Standardization, 2001, ISO 5349-1, Mechanical vibration—Measurement and evaluation of human exposure to hand-transmitted vibration Part 1: General requirements, International Organization for Standardization, Geneva.