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Research Note

Permitted working hours with a motorised backpack sprayer

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Small-scale farmers often use motorised backpack sprayers to apply chemicals to crops. However, vibration from their internal combustion engines and other motive parts, such as pumps, is transmitted to the operator's body and this could cause harm. Vibration signals from a motorised backpack sprayer were measured using 3-axis accelerometers attached to the frame of the sprayer and the operator's wrist, chest, head and neck. The results from fast Fourier transform analysis showed a peak in horizontal vibrations of 3 m s^{-2} at a frequency of 20 Hz. According to ISO-2631-1 standard, this outcome signifies that the maximum continuous working time for practical use for the sprayer under test should therefore not exceed 1 h.

1. Introduction

Small-scale farmers often use motorised backpack sprayers because of their modest cost and adaptability in the field. However, the vibrations from the internal combustion engines and other motive parts in these sprayers are transmitted to the operator's body. A major safety concern for backpack sprayer users has been the adverse effects of exposure to high intensity vibrations on the head, spine and hand resulting in discomfort and early fatigue for the operator. Such fatigue experienced over a period of months and years may cause physical, physiological and musculoskeletal disorders (Mehta, Shyam, Singh, & Verma, 2000). The damage intensity depends on direction, acceleration, magnitude, frequency, ands conditions under which the operator works and the period of usage (Chaturvedi, Kumar, & Singh, 2012).

Agricultural machinery operators report performance difficulties commonly associated with back pain and sitting discomfort (Clijmans, Ramon, & De Baerdemaeker, 1998). For example, low frequency (2–20 Hz) harmonic motions caused by a tractor tyres coming in contact with the soil can place the human body into resonance. During usual working conditions in a field, vibration frequencies between 0.5 and 10 Hz are sent to the seat and can influence the health of the driver. Just 1 h of seated vibration exposure has been shown to cause muscle fatigue, weaken the soft tissues and make a worker more susceptible to back injury (Hostens & Ramon, 2003).

Much research has been carried out to improve the riding comfort of agricultural vehicles and focused on driver seat and cabin vibration (Cuong, Zhu, & Zhu, 2013; Ebrahimi, Esfahanian, & Ziaei-Rad, 2013) but there are few published studies on backpack and hand-carried motorised implements and their vibration effects on the human body. Thus, the

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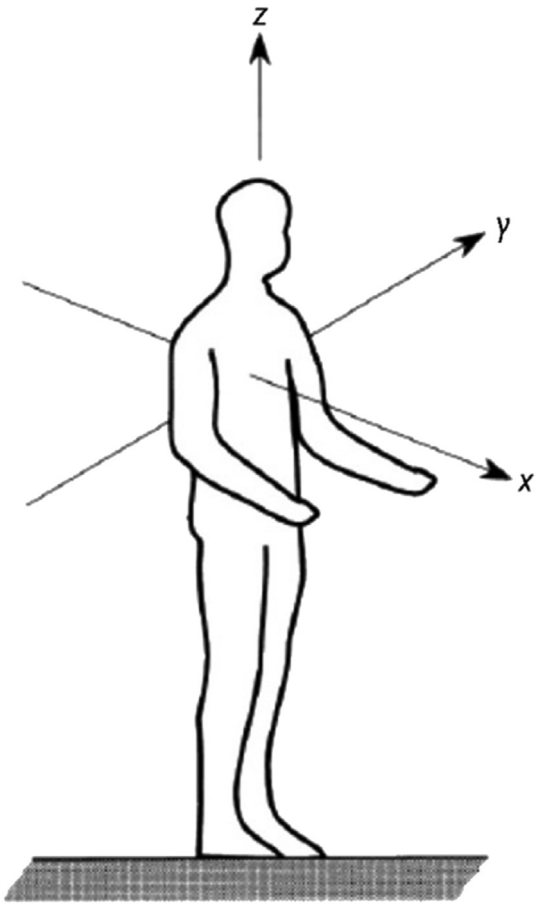

Fig. 1 – Coordinate system used to measure whole-body vibrations.

purpose of the current paper is to present the most relevant results got from vibration frequency domain in operational tests of the motorised backpack sprayer on human body.

Measuring and analysing human vibration signals can help mitigate the negative effects of mechanical vibration on the human body. There are different standards on limit value for whole-body vibration, but because the human body is more sensitive in the range 1–80 Hz the allowable daily exposures with vibration frequencies in this rage are presented in standard ISO-2631-1 "Mechanical vibration and shock, evaluation of human exposure to whole-body vibration" (ISO, 1997). Figure 1 shows the coordinate system used to measure whole-body human vibration, as defined by ISO-2631-1 (ISO, 1997). A further standard, ISO-5349-1 (ISO, 2001), explains the method of measuring of human vibration signals.

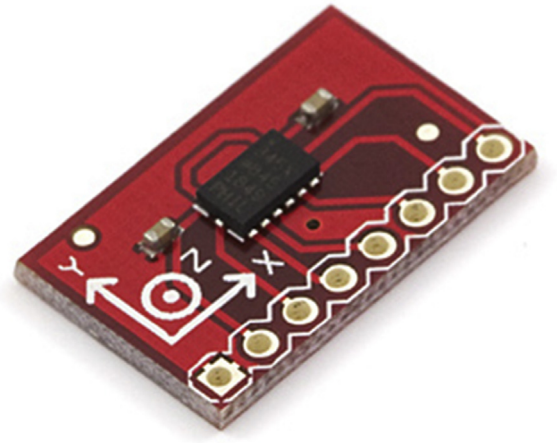

Fig. 3 – A three-axis accelerometer (ADXL345).

2. Materials and methods

A typical motorised backpack sprayer (TF 800 – Farmate Co, China) fitted with a single cylinder two-stroke engine (TU-26 with 6.7 kW at 6000 rpm speed) was used in tests (Fig. 2). The backpack harness consist of two vertical and one horizontal belts with plastic buckles with the frame rigidly mounted on the operator's back.

A Lutron (DT-2234BL, Taiwan) laser photo tachometer measured the rotational speed of sprayer engine. Three-axis accelerometers (ADXL345) with high resolution (13-bit) capable of measuring up to ± 16 g-forces were used for

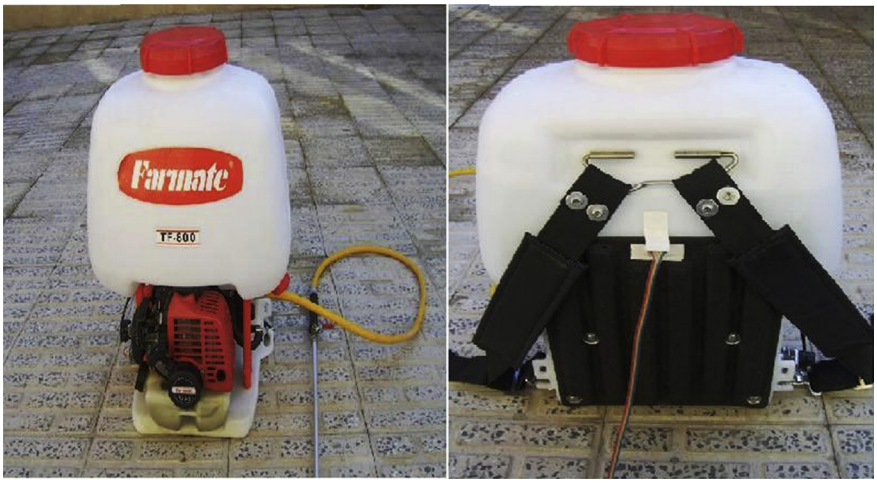

Fig. 2 – Motorised backpack sprayer (Farmate Co, China).