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Effect of coating over the handle of a drill machine on vibration transmissibility

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ABSTRACT

This study was to see the effect of different coatings on the handle of hand-held drilling machines. Out of five different handles chosen for this study, including one handle uncoated. Root mean square (rms) values of the vibration levels (acceleration) were recorded at the surface of handle and wrist of the operators. Results showed that maximum vibrations were reduced by coating of handle coated with rubber sheet and Rexene (H4) followed by handle coated with cotton sandwiched between jeans cloth (H5). Equivalent vibrations transmitted through coating of handles coated with sponge and velvet (H2) and jute and cotton (H3) were of almost same magnitude and these two coated handles were able to reduce least vibration transmitted. Transmissibility of vibrations along dominant (Z) direction was analyzed using ANOVA. Results showed that coating on handles significantly affected vibration transmitted in Z direction. Vibration transmissibility ratios were found to be 0.354, 0.571, 0.408, 0.4326, and 0.3555 for handles H1, H2, H3, H4 and H5 respectively.

1. Introduction

Wide use of hand-held vibrating tools is one of the most important reasons for transmitting vibrations from these tools to the hands, arms and shoulders of the operators. It causes discomfort to the operator and results in early fatigue. When such fatigue prevails over a period of months and years, they may cause physical, physiological and musculoskeletal disorders (Waersted and Westgaard, 1991; Buckle, 1997; Hagberg, 2002). The ill effects of the prolonged exposure to hand–arm vibration on the operators have been known for a long time and the occupational health disorders are referred to as 'vibration-induced white finger (VWF)' or 'hand–arm vibration syndrome (HAVS)' (Taylor and Pelmear, 1975; Hellstrom and Lange Andersen, 1972; Griffin, 1996). For almost a century, workers operating vibration tools on the job have complained symptoms resembling Raynaud's disease. These complaints were related to episodic numbness and tingling of the fingers, episodic blanching of the fingers, the so-called "Vibration-induced White Finger" (VWF) or HAVS (Palmer et al., 2000; Hubbard et al., 2004; Bylund et al., 2002; Weir and Lander, 2005). Many studies have revealed that the workers were not aware of the level of vibration transmitted to hand (Margarita et al., 2008; Hao et al., 2011) whereas in some studies self-reported exposure time estimates were found to be more than actual direct observation estimates (McCallig et al., 2010).

The percentage of workers exposed to hand tool vibration is quite high all over the world. Even in advanced countries like Germany, France, Spain and Finland the percentage varies from 4.6 to 10.9 (Eashw, 2008). The prevalence of exposure was found dominated in construction (63% workers), manufacturing and mining (44%) and agriculture and fishing (38%). In construction industry use of vibratory hand tools is of great concern (DiDomenicoa and Nussbaumb, 2008). Hand–Arm Vibration Syndrome (HAVS) remains a significant occupational health problem as disease symptoms continue to occur even when vibration exposure levels believed to incur low risks. Burström et al. (2004) studied metal workers where tools produced low vibratory exposures with frequency-weighted accelerations between 2.1 and 2.5 m/s^2 but the prevalence of vascular (39%) and neurological symptoms (47%) still existed, with the vascular incidence rate noticed as 24.2 cases per 1000 exposure years.

To have concern about these issues, it is important to know about hand systems response with respect to exposure to vibration. According to biomechanics, the human hand is a very sophisticated and flexible structure. The Biodynamic response distributed on the fingers is very different from that distributed on the palm of the hand (Dong et al., 2005). Therefore, the energy transmission and

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absorption at these two parts of the hand could also generally be very different (Dong et al., 2004). Because the transmitted vibration is likely to be more closely associated with the vibration-induced health effects, it is important to characterize and understand the transmitted vibration. Whereas the vibration transmissibility in the hand–arm system excited from a single-axis vibration exciter has been studied in controlled laboratory conditions by many researchers (e.g., Reynolds and Angevine, 1977; Pyykkö et al., 1976; Gurram et al., 1994; Sörensson and Lundström, 1992, Marcotte et al., 2005; Dong et al., 2006a,b), the characteristics of vibration transmissibility, especially those under real working conditions, have not been sufficiently investigated. However little information on the vibration transmitted to the hand–arm system during the operations of drilling machines is available in literature.

Although the relationship between such disorders and physical characteristics of vibration (frequency, magnitude and direction) is not yet known completely, it is generally agreed that onset of these disorders can be reduced through a reduction in magnitude of vibration transmitted to the hand. It is often recommended that the handle surface should be smooth and slightly compressible (Konz 1990; Mital and Kilbom, 1992b). The arguments for this recommendation are that it is easier on the hand, it distributes the surface pressure more evenly in the hand and also that it is vibration attenuating, compared with an incompressible material. Apart from this vibrations transmitted to hand arm caused by power tools also vary for different postures of hand (Joshi et al., 2012). When studying handle design it is of great importance to have reliable and relevant information regarding all aspects of the handle. Handle is main part of the power tools through which vibrations are transmitted in human body. Hence to reduce risk factors associated with hand arm vibration, it is necessary to improve the handle design so that vibration transmitted could be reduced. Reducing the magnitude of the vibration transmitted from a tool to the hand has been viewed as a potential effective approach to prevent hand–arm vibration syndrome (Griffin, 1990; Pelmear and Wasserman, 1998; Cherng et al., 2009; Morioka and Griffin, 2009; Mallick, 2010). There are two simple ways of reducing vibrations transmitted from power tools to the hands. One is to use gloves and second one is to use coating on the handles through which vibrations are transmitted to hands.

The use of gloves has been demonstrated to have both positive and negative influences on hand exertion. Wearing gloves reduces hand movement and dexterity, and hence increases the performance time needed to complete the task (Plummer et al., 1985; Bellingar and Slocum, 1993; Bensel, 1993; Muralidhar and Bishu, 1994). Some studies reported that wearing gloves reduces the grip force as compared with the barehanded condition (Sudhakar et al., 1988; Wang, 1991; Hallbeck and McMullin, 1993; Shih et al., 1995). Furthermore, the vibration energy transmitted to and absorbed by the hand–arm system results in relative compression and extension of tissues (Reynolds, 1977). The results of gloves influencing the hand-transmitted vibration reported in published reports are varied. When operating a pneumatic chipping hammer, Goel and Rim (1987) indicated that the use of leather, Porton padded and Sorbothane padded gloves, all reduce hand-transmitted vibration as compared with the barehanded condition. On the other hand, the report of Gurram et al. (1994) revealed that the gloves do not yield an effective attenuation of hand-transmitted vibration caused by hand-held powered tools. Most of commercially available antivibration gloves did not attenuate vibrations below 100 Hz (Sampson and Van Niekerk, 2003) and only reduce high frequency vibrations (Smutz et al., 2002). In case of gloves vibration perception at different location on the hand arm system could vary (Dong et al., 2010a,b) indicating effectiveness of antivibration gloves to be location oriented.

Another important approach is coating using damping materials on tool handle that can be used for preventing or reducing the amount of vibration transmitted to hand from the power tools. Some of the problems associated with gloves may be eliminated by using coating on the handle. But the materials which are used to reduce vibrations are of very high cost. In countries like India contractors are not ready to use expensive tools. Therefore task is really challenging in developing and underdeveloped countries to find cheaper ways to reduce problems due to hand-transmitted vibrations. Hence it is important to develop coatings which are relatively cheap so that these can be used in developing and underdeveloped countries to overcome the workers problems as in these countries even the laws are not so strict regarding compensation and other facilities for workers. In the present study different coatings were used on the handle and their effect on the vibration transmitted at the hand and wrist was investigated.

2. Method

2.1. Approach

Vibrations are transmitted from power tools to the hands of operators. The transfer of vibrations from machine to operators can be reduced either by wearing gloves or by providing coating on the surface of handle. Coating of handle is preferable over wearing gloves as these are integrated with machine itself and overcome many problems associated with gloves. Isolation of vibration was done in this experiment by coating the handle with some of very common materials easily available at a very less cost. Hence this experiment was to investigate the effect of different coating materials on the amount of vibration transmitted to the hand of operators.

2.2. Participants

Five male participants (Right handed college students) volunteered to participate in this experiment. All were healthy with no history of neuromuscular or vascular disorders. The subjects showed their interest to voluntarily participate in the study. Their consent was taken prior to start of the experiment. The mean age, mean height and mean mass of the subjects were found to be 23.5 years, 167.69 cm, and 64.8 kg respectively.

2.3. Coating material

Five wooden handles were prepared in the carpentry shop of the college. The reason for choosing wood as material for making handle was its ease of manufacturing, good strength and capability of damping vibrations transmitted through it. Moreover it was possible to attach and remove the handles as per the requirement of experiments performed. One handle was kept bare whereas other four were coated with different materials commonly available as shown in Table 1. Major properties considered for selecting material were vibration damping, comfortable in holding, long life, cheap and easy availability.

Table 1
Type of handles with description of coatings to reduce transmitted vibrations (refer Fig. 1).

S. no	Handle name	Coating material
1	H1	Uncoated
2	H2	Coated with sponge and velvet
3	H3	Coated with jute and cotton
4	H4	Coated with rubber sheets and Rexene.
5	H5	Coated with cotton sandwiched between jeans cloth