ERGONOMIC MODIFICATION AND EVALUATION OF CHAIN SAW HANDLE IN WOOD CUTTING

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1. INTRODUCTION

Human response to vibration depends on magnitude, frequency and direction of the vibration signal (Griffin, 1990). Prolonged exposure to hand-transmitted vibration (HTV) from powered processes or tools is associated with an increased occurrence of symptoms and signs of disorders in the vascular, neurological and osteoarticular systems of the upper limbs (Bovenzi, 1997). The relevance of studying hand–arm vibration in power tools for industry is highlighted by a statistical portrait revealing that 17% of European workers report being exposed to vibration from handheld tools or machinery for at least half of their working time. In the same study, about 13% of workers consider that their work affects their health in the form of muscular pain in the upper limbs (European Commission, 2002). Pocekay et al. (1995) reported that heavy workload, inadequate equipment design, high production demands and repetitive wafer-handling activities are risk factors associated with musculoskeletal disorders for semiconductor industry workers. It is also reported that a handle angle design affects wrist posture and lifting capability (Wang et al., 2000). The present study was designed to reduce vibration-induced stresses in wood cutting using a chain saw, through handle design. To achieve these objectives, the study was carried out in two phases: pilot and main experiments.

2. PILOT EXPERIMENT

The pilot experiments were performed prior to main investigations, to record the postural angles of wrist, forearm and index finger and the vibration levels.

2.1. Angular Deviations of Wrist and Forearm

Two healthy male participants participated in the experiment. A twin axis goniometer (SG65) and single axis torsiometer (Q150) goniometers were attached to the left hand with die cut medical grade double sided adhesive tape (T350). The participant was asked to hold the tool for comfortable posture, and then to operate the tool for one minute.

2.2. Transfer of Vibration to the Hand-Arm System

Data acquisition was made possible using tri-axial transducer (Model No. SEN041F made by PCB Piezotronics, New York, USA) that was connected to NI card. The transducer was placed as required by ISO 5349-2 (2001). The setup supported a sampling rate of 1024 per second. A LabVIEW code was written for the recording of Vibration levels.

2.3. Results - Pilot Experiment

Angular deviation

From Figure 1, it was found that the torsion angular deviations were high for both left and right hands. Deviations of the wrists were also large in the radial/ulnar directions, with left wrist deviation larger than the right.

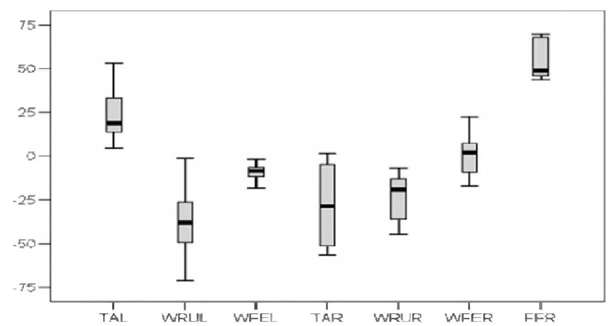


Figure 1. Torsion Angle, left (TAL) & right (TAR) Wrist Radial/Ulnar Angle, left (WRUL) & right (WRUR), Wrist Flexion/Extension Angle, left (WFEL) & right (WFER) Finger Flexion Angle (FFR)

Vibration Levels

The analysis for vibration was done using MATLAB. The vibration of the chain saw was high, but the component vibration in three directions (X, Y & Z) can be reduced by making new handles of different material having high vibration damping properties.

3. MAIN EXPERIMENT

Based on the findings of pilot experiment, three different angled handles were used for the investigations, with 30°, 60°, and 90° inclinations in the downward direction from the horizontal axis. Four healthy male subjects participated in the main experiment. Vibration levels were recorded in three directions (X, Y and Z) at the wrist position with the old and new designs of handles. Observations were recorded as in the pilot experiment.

4. RESULTS AND DISCUSSION

In Figure 2, it can be seen that the deviation in the torsion angle was lowest for the 30° handle and highest for the original handle (180°), during chain saw operation. For the wrist radial/ulnar angle, the 30° and 90° handles have similar angular deviation, and these were the minimum values of radial/ulnar deviation among all handles tested. The angular deviation for radial/ulnar of the 60° handle was greater than that of both the 30° and 90° handles, but was less than that of the original handle.

Figure 2. Postural angles for modified and original handles.

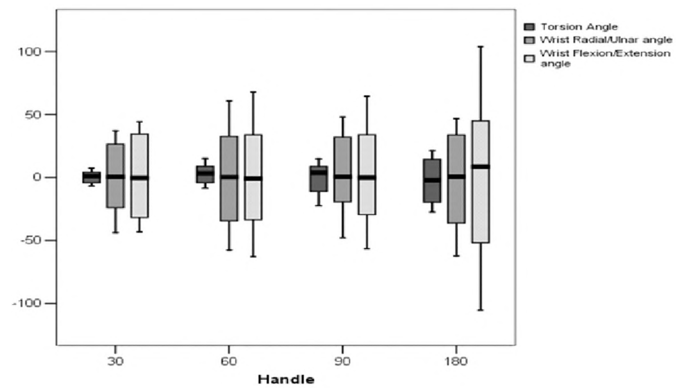
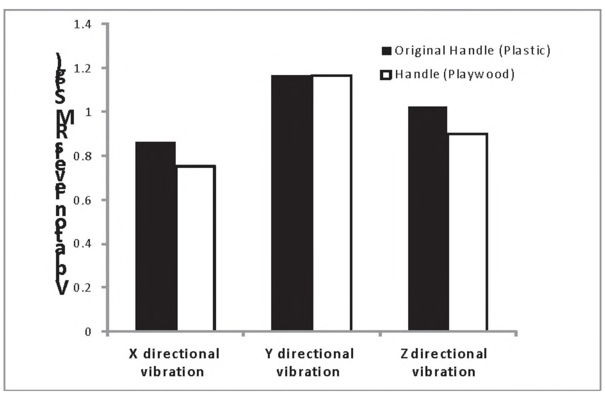


Figure 3. Vibration levels for original and new handles



Vibration levels were also observed to be lower with new design of handles than the old design. The results in Table 3 showed the levels of vibration produced in the new handle were lower in X and Z directions. Reduction in handle vibration levels can be attributed to the new handle material. The old handle was plastic, and the new handle was made of cross-ply laminated plates; vibration absorption of laminated plates is greater than that of the plastic. The similar studies were done with different power tools in previous research (Xu et al. 2009; Dong et al. 2003; Chang et al. 2000; Vergara et al. 2008; Rimell et al. 2008).

Similar findings on wrist angle deviations were described by Okunribido & Haslegrave (1999), who performed a study on the effect of handle design for cylinder trolleys. Chung & Wang (2001) also found that modifying the grasp handle on a pod in wafer-handling tasks induced less ulnar deviation, but significantly greater radial deviation. They further found that radial deviation could be reduced by tilting the handle angle from 90° to between 30° and 45°. The wrist radial deviation problem was thus improved. The results by ANOVA showed that only the minimum value for the flexion/extension angle was significant ($p<0.01$).

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