MEASUREMENT AND EVALUATION OF THE VIBRATION TRANSMISSIBILITY OF GLOVES

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Abstract

The increasing attention is paid to the protection of the operator of the mechanized working tool from the vibration. The paper presents research results of the vibration transmitted from the chain saw rear handle to the operator's hand without gloves and when five different type of antivibration gloves were used. The vibration levels were measured at idling, full load and cutting. The vibration levels were measured and analyzed and the frequency spectra for the chosen working conditions were obtained. The frequency-weighted acceleration, given in m/s^2, was calculated. The vibration total value was defined as the root-sum-of–squares of the three component values. The obtained values are graphically representing.

Key words: *ergonomics, hand-arm transmitted vibration, antivibration gloves, protection*

INTRODUCTION

Machine operators are usually exposed to two types of vibration: whole-body vibration transmitted via seat or via the floor and feet, and hand-arm vibration which is vibration transmitted from work processes into worker′s hands and arms. It is usually caused by operating hand-held power tools. Regular and frequent exposure to hand-arm vibration can lead to permanent health effects. Hand-arm vibration can cause a range of conditions known as hand-arm vibratin syndrome (HAVS), as well as specific diseases such as carpal tunnel syndrome. To quantify vibration exposure, measurement must be taken under representative conditions. Guidelines for measuring and evaluating human exposure to the hand-arm transmitted vibration and details of different analysis methods are given in ISO 5349-1-2001. It has been estimated that 1.7-3.6% of the workers in the European countries and the USA are exposed to potentially harmful hand-transmitted vibration. Vascular disorders and joint abnormalities caused by hand-transmitted vibration are compensated occupational diseases in 13% of total occupational diseases in Croatia (Kacian, 1997). These disorders are also included in an European list of recognized occupational diseases. Although it is a very serious problem in several countries, small attention has been paid to it.

In order to improve the damping characteristics of the five types of the so called *antivibration gloves,* the complex measurements were carried out on the rear handle of the chainsaw. The paper presents research results of the vibration transmitted from the chain saw rear handle to the operator's hand without gloves and when five different types of *antivibration gloves* were used. The vibration levels were measured and analyzed and the frequency spectra for the respective working conditions were obtained. The frequency-weighted acceleration, given in m/s^2, was calculated. The vibration total value was defined as the root-mean–square of the three component values. The obtained values are graphically represented.

MATERIAL AND METHODS

In the ISO 5349 recomendation, the most important quantity used to describe the magnitude of the vibration transmitted to the worker′s hand is the root-mean-square frequency weighted acceleration expressed in m/s^2. In addition, it is strongly recommended that for additional purposes frequency spectra should be obtained. Acceleration values from one-third-octave band analysis can be used to obtain the frequency-weighted acceleration a_{hw}. It shall be obtained using:

$$a_{h,w} = \left[\sum_{j=1}^{n} (w_j \cdot a_{wj})^2 \right]^{1/2}$$

where a_{wj} is the acceleration measured in the *j*th one-third-octave band in m/s^2, and W_j is the weighting factor for the *j*th one-third-octave band.

It is known that the vibration entering the hand contains contributions from all three measurement directions. Therefore, the measurement should preferably be made for all three directions simultaneously. In accordance with ISO 8727 the three directions of an orthogonal coordinate system in which the vibration acceleration should be measured is shown in Fig.1. For practical measurements, the orientation of the coordinate system may be defined with reference to an appropriate basicentric coordinate system originating in vibrating handle gripped by the hand.

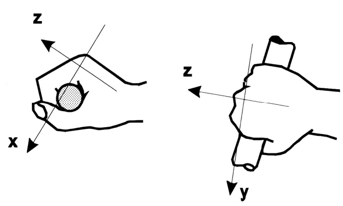

Figure 1. Coordinate system for the hand

The evaluation of the vibration exposure in accordance with ISO 5349 is based on a quantity that combines all three axes. This is the vibration total value a_{hv} and it is defined as the root-sum-of-squares of the three component values (weighted acceleration sum – **WAS**):

$$a_{hv} = \sqrt{a_{hwx}^2 + a_{hwy}^2 + a_{hwz}^2}$$

where a_{hwx} , a_{hwy} , a_{hwz} are frequency-weighted acceleration values for the single axes.

The intention of the research was to define the vibration exposure level of the hand-arm-transmitted vibration with and without *antivibration gloves* from the chain saw rear handle to the worker's hand. The research was carried out on the ***STIHL MS440*** chain saw and the following four types of antivibration gloves were tested:

- *STIHL*
- *Santinni*
- *W&W*
- *Good Year.*

The measurements were carried out on a randomly chosen standard chain saw. Before testing the chain saw was examined and adjusted following the producer's recommendations. The vibration levels transmitted to the worker's hand were measured under three operating conditions:

· at idling,
· at full load and
· at cutting.

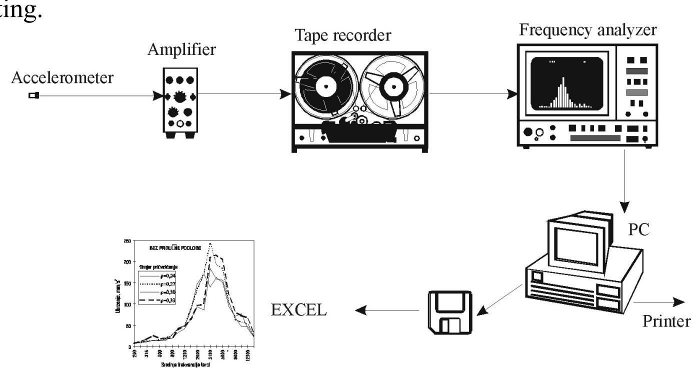

Figure 2. Shematic presentation of the equipment used for vibration measurements and analysis

The measurement procedure was in accordance with ISO 5349-1-2001. The vibration levels were measured in all three axes simultaneously. For all three axes in all operating conditions the frequency spectra were obtained. The vibration measurements and analyses were carried out using the measuring chain shown in Fig. 2. All components of the measuring chain are Bruel&Kjaer products and they all meet the requirements stated in the recomendations of the IEC publications No. 651, 225, 184 and 222. For each operating condition eight independent measurement values were taken. Based on eight measurement values the arithmetic mean value of the acceleration values from one-third-octave band analysis. During measurement the accelerometers were located as it is recomended in ISO 5349-2-2001.

RESULTS

Measurement results can be grouped as follows:

· acceleration values obtained from one-third-octave band analysis for all three operating conditions and their presentation in accordance with ISO/DIS 5349-1979

· frequency weighted accelerations and the vibration total values for all three operating conditions – weighted acceleration sum (WAS) values and their graphical representation

a) acceleration values obtained from one-third-octave band analysis for all three operating conditions and their presentation in accordance with ISO/DIS 5349-1979:

Frequency spectra were obtained for all three single axes and for all three operating conditions. The results are graphically represented in Figs. 4-12 (linear scale for ordinate left, logaritmic scale with corrective factor right). Excessively line indicates vibration transmitted to the workers hand-arm without gloves.

X-axes:

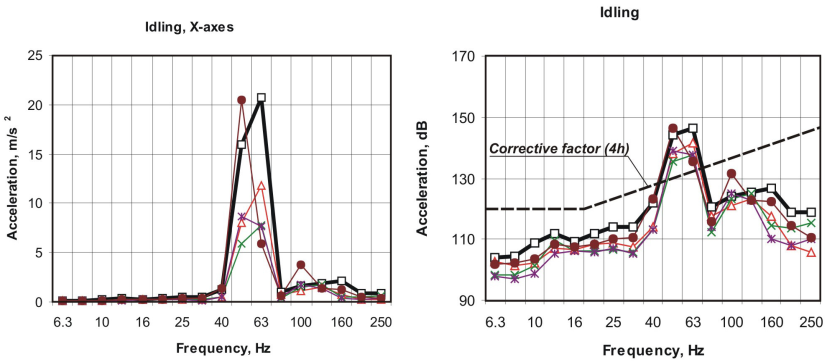

Figure 4. Frequency spectra arithmetic values of accelerations of eight measurements for X-axes at idling

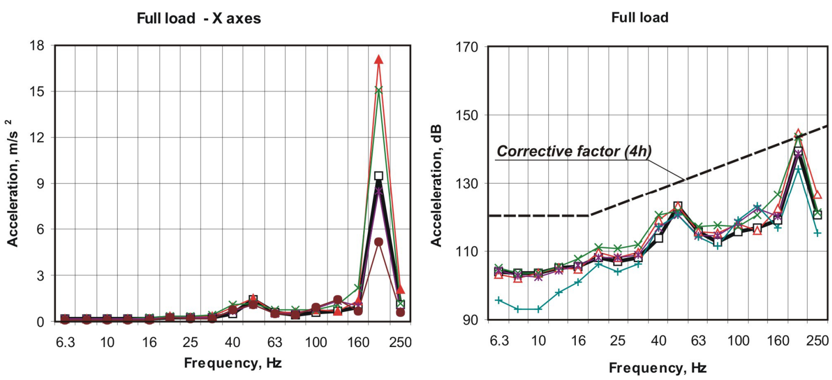

Figure 5. Frequency spectra arithmetic values of accelerations of eight measurements for X-axes at full load

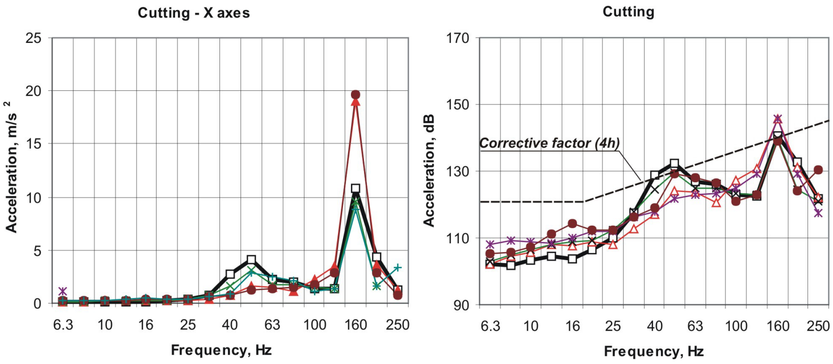

Figure 6. Frequency spectra arithmetic values of accelerations of eight measurements for X-axes at cutting

Y-axes:

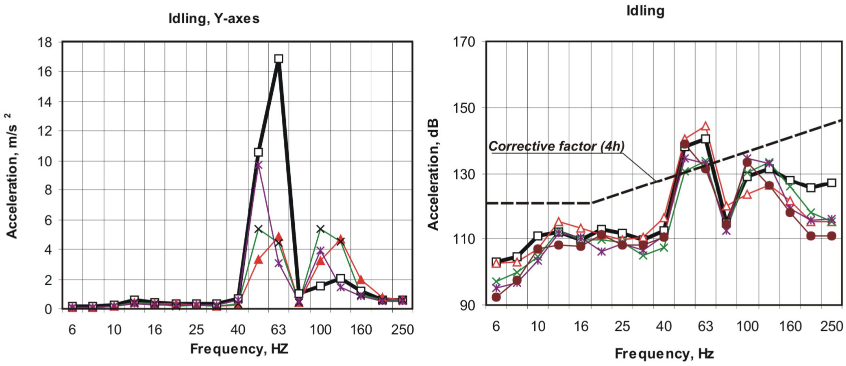

Figure 7. Frequency spectra arithmetic values of accelerations of eight measurements for Y-axes at idling

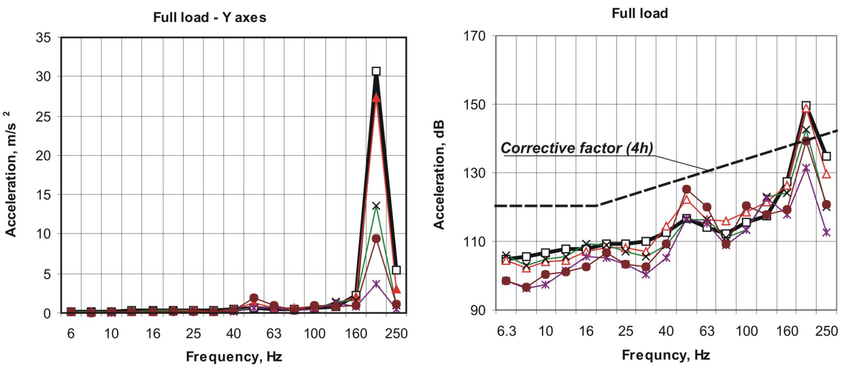

Figure 8. Frequency spectra arithmetic values of accelerations of eight measurements for Y-axes at full load

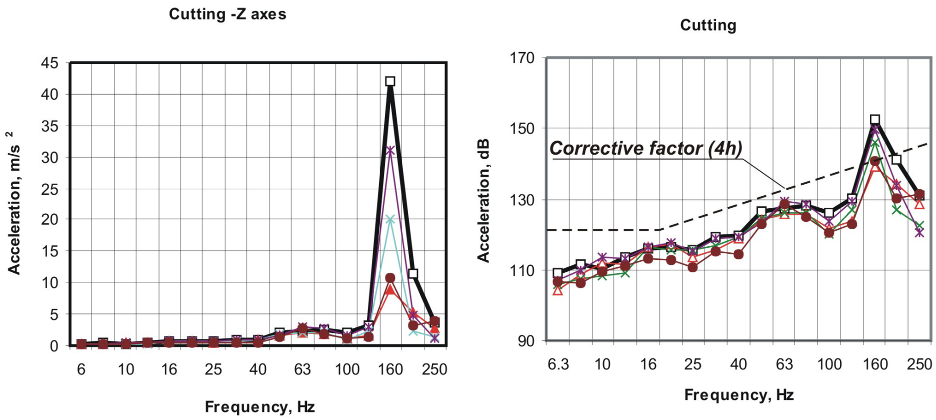

Figure 9. Frequency spectra arithmetic values of accelerations of eight measurements for Y-axes at cutting

Z-axes:

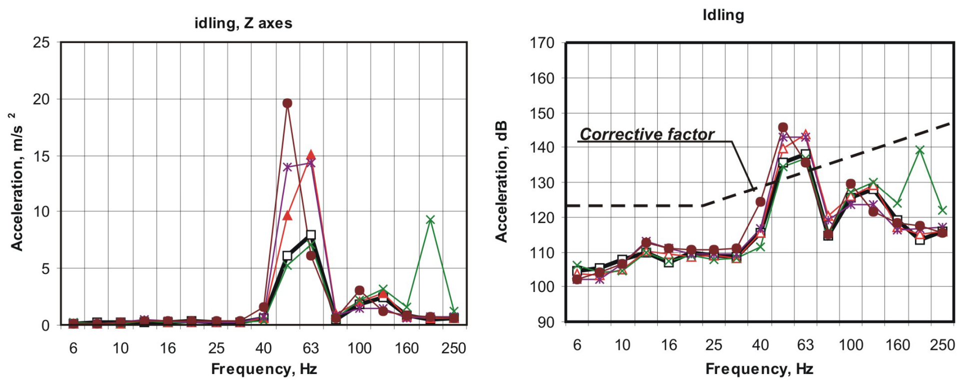

Figure 10. Frequency spectra arithmetic values of accelerations of eight measurements for Z-axes at idling

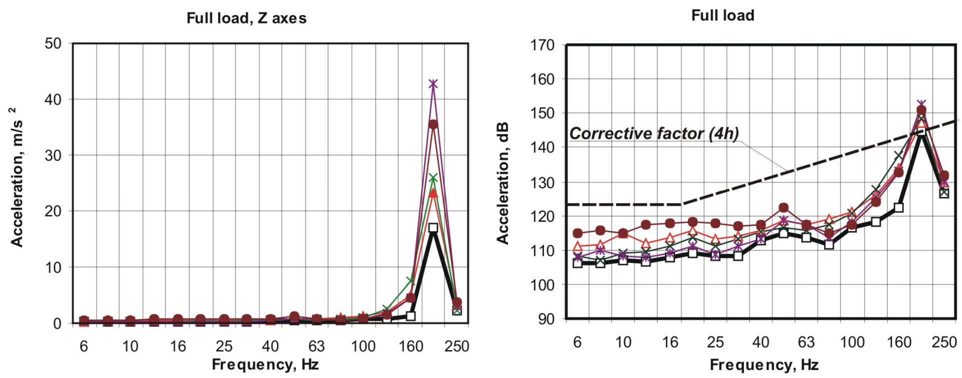

Figure 11. Frequency spectra arithmetic values of accelerations of eight measurements for Z-axes at full load

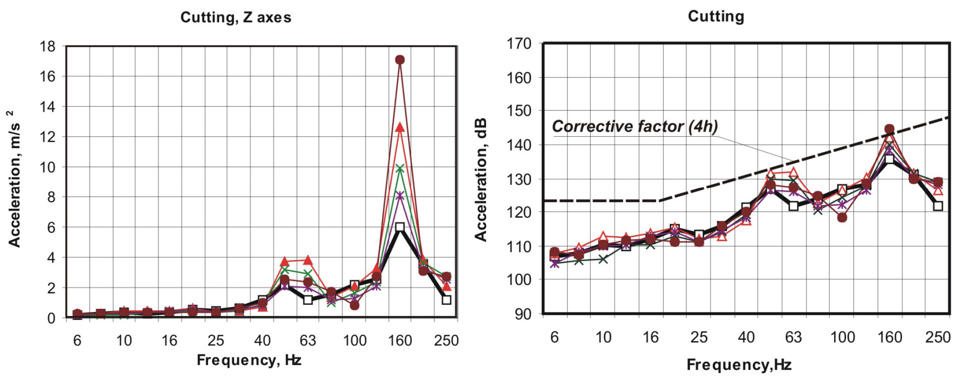

Figure 12. Frequency spectra arithmetic values of accelerations of eight measurements for Z-axes at cutting

b) frequency weighted accelerations and the vibration total values for all three operating conditions – weighted acceleration sum (WAS) values and their graphical presentation:

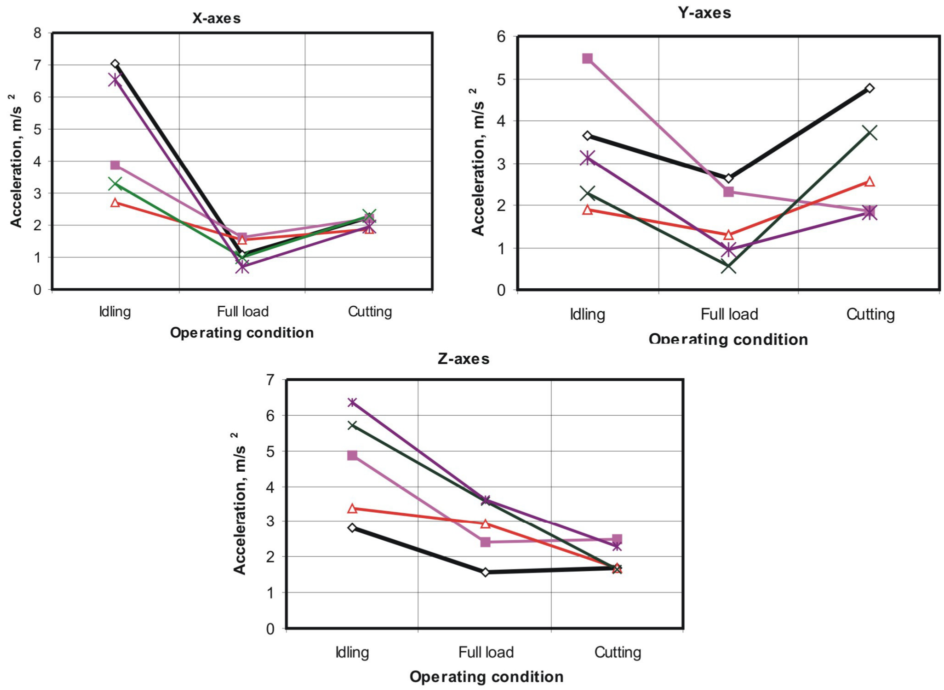

Figure 13. Frequency weighted accelerations for all three axes and for all three operating conditions

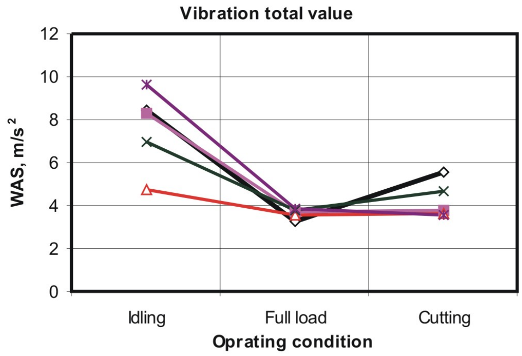

Figure 14. Vibration total energy equivalent value- weighted acceleration sum (WAS)

CONCLUSION

The research results suggest that the protective *antivibration gloves* do not provide adequae protection to the chain saw operators. Not a single measurement result has reliably indicated that the level of the hand-arm transmitted vibration has been reduced when using *antivibration gloves*.

The result of this research are comparable to those of some previous research in the field. The same conclusion was reached by Griffin M.J.(6) one of the world's greatest authorities on human vibration. But there are also others, with different opinions, as for example, Jetzer et.al. (7) who concludes that workers without *antivibration gloves* were more likely to show progression of symptoms of hand-arm vibration syndrome (HAVS), so that these findings suggest that ergonomicintervention can be effective in controlling the workplace hazard of tool vibration.

REFERENCES

1. Goglia V: Ergonomic parameters of forest mechanisation – measuring and evaluation problems. *Mehanizacija sumarstva* 1996, **22**, 209-217.

2. ISO 5349: *Mechanical vibration – guidelines for the measurements and assessment of human exposure to hand-transmitted vibration. Part 1: General requirements*. International Standard Organization, Geneva; 1986.

3. ISO 5349-1: *Mechanical vibration – measurement and evaluation of human exposure to hand-transmitted vibration. Part 1: General requirements*. International Standard Organization, Geneva; 2001.

4. ISO 5349-2: *Mechanical vibration – measurement and evaluation of human exposure to hand-transmitted vibration. Part 2: Practical guidance for measurement at the workplace*. International Standard Organization, Geneva; 2001.

5. Kacian N: Occupational diseases in Croatia. *Work and Safety* 1999, **3**, 83-89.

6. Griffin, M.,J. *Handbook of Homan Vibration*, Academec Press Harcourt Brace& Company, New York 1996.

7. Jetzer, T., Haydon, P., Reynolds, D. Effective intervention with ergonomics, antivibration gloves, and medical surveillance to minimize hand-arm vibration hazard in the workplace, Occupational Enviromental Medicine, 2003, **45** (12), 1312-7