Effect of Steering Wheel Vibration on drivers Hands in a Two-Wheel Drivers Hand tractor

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Abstract

The paper presents research results of the vibration transmitted from the steering wheel of the tractor with a 2-wheel drive to the driver's hands. The vibration measurements were carried out on the tractor randomly chosen from the collage of agriculture / university of Baghdad. Before testing the tractor was examined and adjusted following the producer's recommendations. The vibration levels were measured during the operation tillage at idling and at full load .The field was 3١,٧ m above level sea. Soil was treated at soil constant moisture (1٧-20 %) with depth of plowing (١٧ cm). During operation the weather temperature was measured (15 C) and humidity was (27 %) The vibration level on the steering wheel was measured and analyzed .The frequency-weighted acceleration(RMS) , given in $m/\sec^2$, was calculated. The vibration total value was defined as the root-mean-square of the three component value.

الخلاصة :

البحث يوضح تأثير الاهتزاز المنقول من عجلة القيادة إلى أيدي سائق جرار ثنائي الدفع . تم قياس الاهتزاز لجرار اختير عشوائياً من جرارات كلية الزراعة – جامعة بغداد . قبل أجراء التجربة تم تحضير الجرار حسب التوصيات المصنعية . مستويات الاهتزاز قيست خلال أجراء عملية حراثة عند تحميل المحرك الكامل والقليل . حقل التجربة يرتفع ٣١,٧ متر فوق سطح البحر . أجريت معاملة التربة عند رطوبة ثابتة (17- ٢٠ %) وبعمق حراثة (17 سم) . درجة الحرارة كانت (١٥مئوي) والرطوبة النسبية (٢٧%) . مستوى الاهتزاز المنقول من عجلة القيادة تم قياسه وتحليله . وقياس تردد التعجيل المثقل (جذر مربع المتوسطات) بوحدة متر / ثانية تربيع . قيمة الاهتزاز الكلي عُرفت كجذر مربع المتوسطات للاتجاهات الرئيسة الثلاث .

Keywords: Ergonomics, Hand-transmitted vibration, Tractor, vibration exposure, steere wheel .

Introduction

The operators of the single-axle tractors (also known as two-wheel, walking or hand tractors) are especially exposed to hand-arm transmitted vibrations.

Farm tractors and other earth-moving equipment contribute to some of the most common, prolonged, and severe occupational exposures of vehicle vibration among equipment operators. The recognition of potential hazards has resulted in standards concerned with the vibration transmitted by the seats (ISO 5007, 2003) of these vehicles and the vibration exposure (ISO 5008, 2002) of vehicle operators (Griffin, 1990).

Exposure to whole-body vibration (WBV) and the postural requirements of the job have been identified as important risk factors in the development of musculoskeletal disorders (MSD) of the spine among workers exposed to a vibratory environment (Kittusamy and Buchholz, 2004; Kittusamy, 2002, 2003. Several investigators (Wikstrom et al., 1994; Seidel, 1993; have reported on the adverse health effects of WBV. NIOSH compiled a comprehensive body of epidemiological research presenting risk factor exposures for MSD, such as repetition, force, posture, and WBV. Acute health effects include loss of visual acuity, postural stability and manual control; whereas chronic health effects include low-back pain, early degeneration of the spine, herniated discs, and digestive and circulatory disorders. Long-term exposure to WBV may also contribute to disorders of female reproductive organs and disturbances of pregnancy (Seidel, 1993; Seidel and Heide, 1986). Furthermore, WBV may synergistically affect the development of noise-induced hearing loss (Seidel, 1993).

From experiments using percutaneous pin-mounted accelerometers, they determined resonances at fairly uniform frequencies for all subjects tested, first within a band of 4.5–5.5 Hz and subsequently in the 9.4–13.1-Hz range. They concluded posture, seating, and seat-back inclination affected the frequency response and that rocking of the pelvis essentially determined the response.

Vibration can produce a wide variety of different effects to the operators. Machine operators are usually exposed to two types of vibration: whole-body vibration transmitted via the seat or via the floor and feet, and hand-arm-transmitted vibration(Issever 2003). Both forms of vibration contribute to operator fatigue and can have a detrimental effect on job performance and health. To asses the effect of vibration, the vibration intensity and frequency must be taken into account together with exposure time. To quantify vibration exposure, measurements must be taken under representative conditions. Guidelines for measuring and evaluating human exposure and details of different analysis methods are given in ISO 2631-1-1997 for the whole-body vibration and ISO 5349-1 -2001 for the hand-arm-transmitted vibration. Excessive exposure to hand-transmitted vibration can induce disturbances in finger blood flow, and in neurological and motor functions of the hand and arm. It has been estimated that 1.7–3.6% of the workers in the European countries and USA are exposed to potentially harmful hand-transmitted vibration (Kacian, 1997).

These disorders are also included in a European list of recognized occupational diseases (ISO 5349-2001). The term ‘‘hand-arm vibration syndrome’’ (HAVS) is commonly used to refer to the complex of peripheral vascular, neurological and musculoskeletal disorders associated with exposure to hand-transmitted vibration. Although it is a very serious problem in several countries, Small attention is paid to it.

Almost any operator of forestry and agricultural mechanization is exposed to whole-body vibration and/or hand-arm-transmitted vibration. Even operators on jobs that seem easy, such as tractor driver, can be exposed to unexpected vibration. Specially unexpected are vibration transmitted from the steering wheel to the driver's hands. This vibration was already recognized as a problem (Goglia and

Gospodaric 2002). The research which is presented in this paper was carried out on the tractor with a 2-wheel drive.

Material and methods

In the ISO 5349 recommendations, the most important quantity used to describe the magnitude of the vibration transmitted to the driver's hands is root-mean square frequency-weighted acceleration expressed in $m/\sec^2$. 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 ahw: It shall be obtained using (ISO 5008 :2002) :

$$a_{h.w} = \left[\sum_{j=1}^{n} (W_j a_{w.j})^2 \right]^{1/2} \quad (1)$$

Where $a_{w.i}$ is the acceleration measured in the *i* th one third-octave band in $m/\sec^2$, and W_j is the weighting factor for the *i*th one-third-octave band as shown in fig.1.

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.2. For practical measurements, the orientation of the coordinate system may be defined with reference to an appropriate basicentric coordinate system originating in vibrating handle (steering wheel) gripped by the hand.

The evaluation of vibration exposure in accordance with ISO 5349-2001 is based on a quantity that combines all three axes. This is the vibration total value ahv and it is defined as the root-mean-square of the three component values:

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

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

As it was mentioned before, the vibration exposure depends on the magnitude of the vibration total value and on the duration of the exposure. Daily exposure duration is the total time for which the hand(s) is (are) exposed to vibration during the working day. It is very important to base estimates of total daily exposure duration on appropriate representative samples for the various operating conditions.

The daily vibration exposure shall be expressed in terms of the (8 hours) energy equivalent frequency-weighted vibration total value as

$$A(8) = a_{hv} \sqrt{\frac{T}{To}} \quad (3)$$

Where *T* is the total daily duration of the exposure expressed in sec to the vibration *ahv* ; and *T0* is the reference duration of 8 h (28 800 sec).

If the work is such that the total daily vibration exposure consists of several operations with different vibration magnitudes, than the daily vibration exposure, A (8 hours) shall be obtained using:

$$A(8) = \sqrt{\frac{1}{To} \cdot \sum_{i=1}^{n} a_{hvi}^2 \times T_i} \quad (4)$$

Where *ahvi* is the vibration total value for the *i*th operation, *n* is the number of individual vibration exposures, and T*i* is the duration of the *i*th operation.

The intention of the research was to define the vibration exposure level of the hand-arm-transmitted vibration from the tractor steering wheel to the driver's hands. The research was carried out on the tractor with a 2-wheel drive. Condition of tractor rebated be recommended ISO 5008 : 2002 , the tractor shall be in working order with full tank and radiator , but without optional front and rear weight , tire ballast, The tire used in test was stander size for tractor .Mold board plow with Massy Ferguson MF285tractor as one machinery unit figure.3and table1 and 2 .

The vibration levels transmitted to the driver's hands were measured under two operating conditions:

*** At idling.**

*** At full load**.

The measurement procedure was in accordance with ISO 5349-2001. The vibration levels were measured in all three axes simultaneously. For all three axes in both operating conditions the frequency spectra were obtained.

The arithmetic mean value of the acceleration values from one-third-octave band analysis was calculated. The frequency-weighted acceleration was calculated from the arithmetic mean value of the acceleration recommended in ISO 5349-2-2001 (see Fig. 4) The vibration meter have one accelerometer (one sensor) and we take five readers and we calculated the Mean value to each directions X, Y and Z (see table 3)

Calibration vibration meter

The vibration meter which used was type (VB-8201HA) and we make calibration with another vibration meter and gave the same results in each reading

Results

Measurement results can be grouped as follows:

1- frequency-weighted accelerations and the vibration total values for both operating conditions - weighted acceleration sum (WAS) values and their presentation in accordance with ISO 5349-1,-2001, table 3 .

2- The daily vibration exposure was obtained using Eq. (4).During an ordinary working day the driver spends approximately 6.5 h in effective work. The effective work consists of two dominant operations during which the tractor is either idling or at full load. The duration of idling is approximately 1.5 h. Thus, tractor is at the full load for 5 h per working day.

3- Vibration acceleration (R.M.S) increased with increasing velocity of tractor and in full load and decrease at idling and low velocity

Therefore, the total daily vibration exposure can be calculated as follows:

$$A(8)For\ .L1 = \sqrt{\frac{1}{To}\sum_{i=1}^{n} a_{hvi}^{2}\ Ti}$$

$$= \sqrt{\frac{1}{28800}(5400 \times 14.4^2 + 18000 \times 25.2^2)}$$

$$= 20.875\, m/\sec^2$$

$$A(8)ForL\,3 =$$

$$\sqrt{\frac{1}{28800}(5400 \times 19.1^2 + 18000 \times 33.7^2)}$$

$$= 27.896\ m/\sec^2$$

Conclusion

Results of the study showed that the levels of vibration transmitted from steering wheel to hand a driver during the experiment was high comparing with ISO 5349-1: 2001.Velocity of tractor has a strong effect on transmitted vibration to hands driver from steering wheel all three perpendicular axes. Like these value acceleration (rms) effect on driver and caused discomfort, will produce finger blanching, tired, less performance and not completely control operation to the tractor by driver. Therefore, it is necessary that persons who are responsible for occupational health and safety take preventive measures. It is presumed that vibration hazards are reduced when continuous vibration exposures over long period are avoided like take rest period after 2 – 4 hours from beginning work. Therefore, work schedules should be arranged to include vibration-free periods. We can reduce vibration transmit by use Hydraulic steeren wheel and use rubber material to connection steeren parts .

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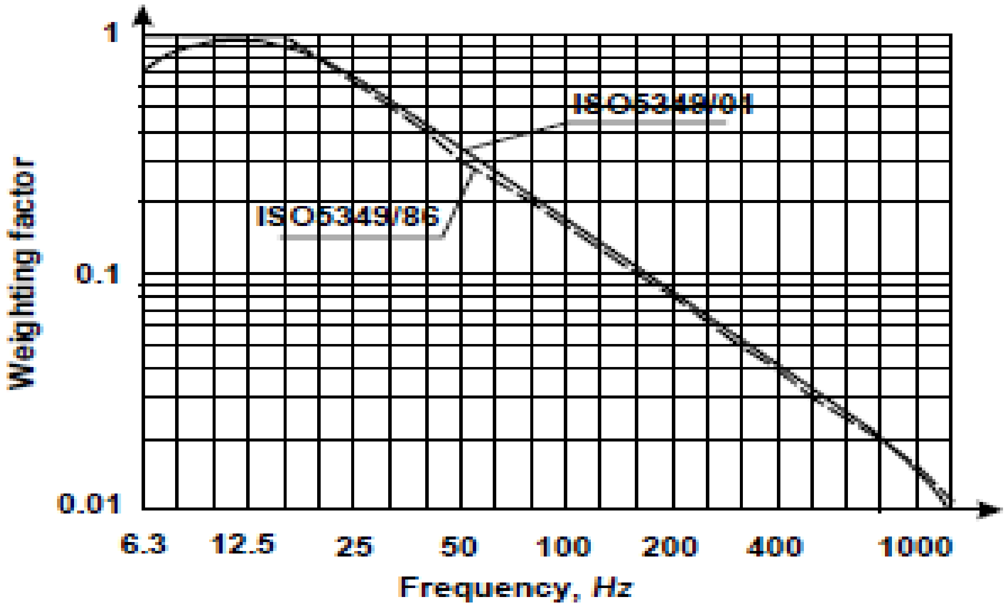


Fig. 1. Frequency-weighting factor curve for hand-transmitted vibration.

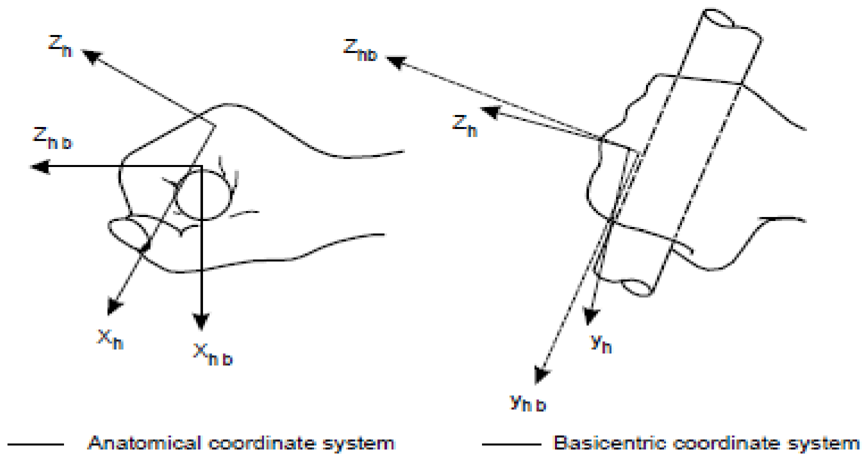


Fig. 2. Coordinate system for the hand (according to ISO 5349).

Fig. 3. Tractor Massy Ferguson MF285 and mold board plow as one machinery unit

Table 1 Tasted tractor – technical characteristics.

Technical characteristics	
Type	Massy Ferguson MF285
Power drive	2- wheel
Type engine	Perkins A4.248 / 4-stroke diesel with direct fuel injection
Cylinders no	4
Stroke length (mm)	115
Bore diameter (mm)	104
Engine power (H.P)	75
Cooling system	liquid force feed with thermostat
Maximal r.p.m	2000
Weight tractor unballasted (KN)	27.30
Tires front size	7-50 R16
Tires front pressure (psi)	35 *
Tires rear size	18-4 R30
Tires rear pressure (psi)	25

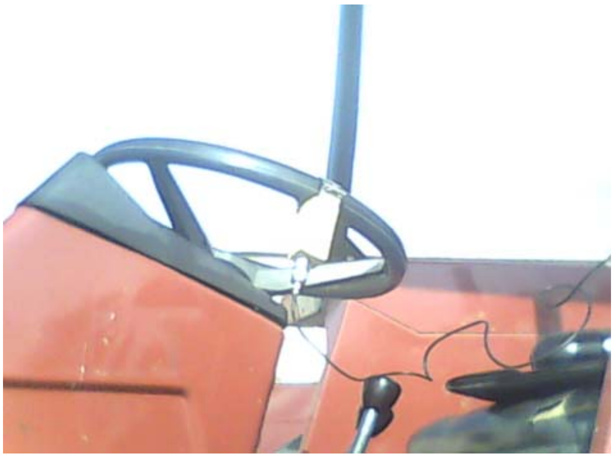
* Tires pressure during the operation.

Table 2 Three furrow mould board plough – specification.

Working width (mm)	1050
Max working depth (mm)	270
Weight (kg)	280

A - Measure longitudinal direction X

B - Measure lateral direction Y



C - Measure vertical direction Z

Fig. 4. Accelerometer locations on steering wheel during measurement.

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Fig. 5 Vibration meter & sensor

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Table 3. Frequency-weighted accelerations and WAS values (weighted acceleration sum) for both operating conditions, $m/\sec^2$.

Gear box No	Acceler direction	Measuring No 1	2	3	4	5	Mean value
L1*	(a)**						
	X	5.4	5.2	5.6	5.8	5.4	5.5
	Y	4.3	4.1	4.5	4.4	4.3	4.3
	Z	12.5	13.6	12.2	12.0	12.7	12.6
	WAS						14.4
	(b)***						
	X	13.2	14.1	14.0	13.5	13.8	13.7
	Y	11.1	10.5	10.6	11.3	10.9	10.9
	Z	19.6	17.0	17.5	17.8	18.6	18.1
	WAS						25.2
L3	(a)						
	X	6.4	6.2	6.8	7.1	7.4	6.8
	Y	5.4	5.2	5.1	5.8	5.6	5.4
	Z	17.6	16.5	16.8	17.2	17.0	17.0
	WAS						19.1
	(b)						
	X	16.7	16.1	16.3	17.2	17.5	16.8
	Y	11.9	11.6	12.0	12.4	12.8	12.1
	Z	25.3	26.2	26.0	27.5	28.0	26.6
	WAS						33.7

* L1 is referring to gear number One from the gear box.
L3 is referring to gear number three from the gear box
** (a) at idling without operation tillage.
*** (b) at full load with operation tillage.

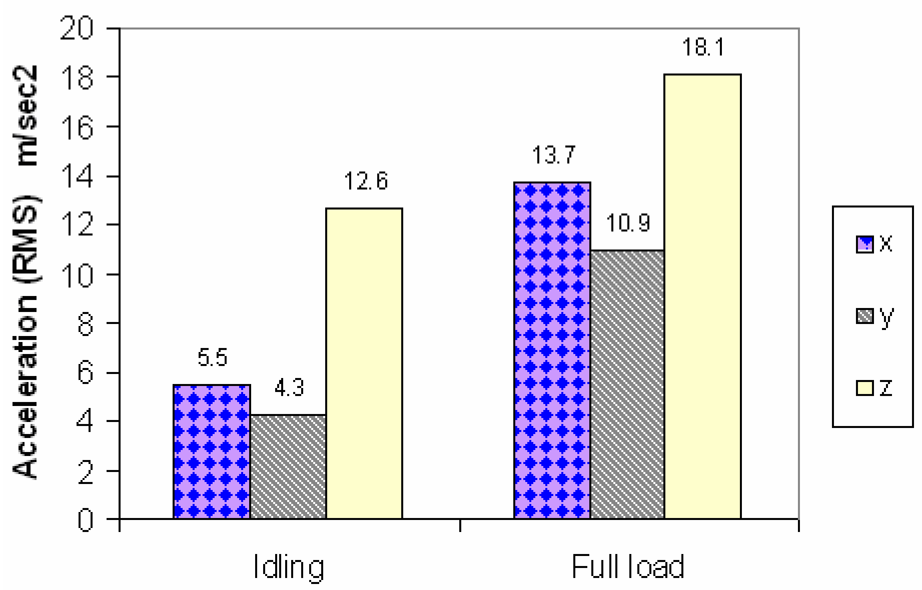

Fig.6. Mean Values of Acceleration (RMS) of three measurements of both operation conditions (X-Y-Z direction) on L1 GEAR BOX.

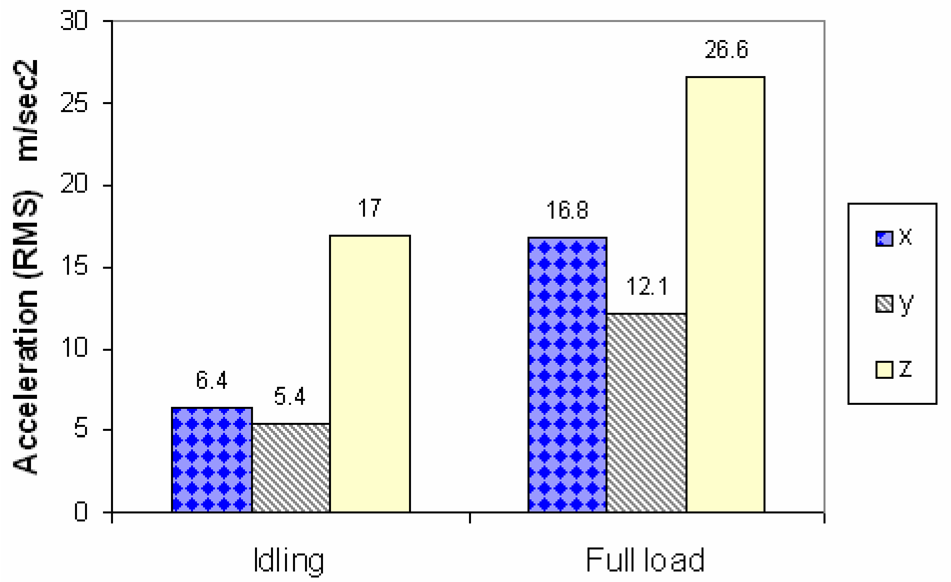

Fig.7. Mean Values of Acceleration (RMS) of three measurements of both operation conditions (X-Y-Z direction) on L3 GEAR BOX.