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EFFECT OF HARVESTER COMBINES LOAD ON VIBRATION DOSE VALUES

Ayad Jameel Alkhafaji[1*] and Abdulaziz A. Almosawi[2]
[1]Faculty of Agriculture, University of Kufa, Iraq
[2]University of Al-Forate Alawsat, Iraq
*Corresponding author E-mail : iyad.alkhafaji@uokufa.edu.iq.

Abstract

Vibration is a real source of danger to agricultural machinery operators, those working long hours during the day. Therefore, the aim of the research was to assess the vibration of a combine harvester driver, various methods of expressing vibration were used in order to determine the most appropriate way to clarify the risk to the driver. Harvest drivers work during the harvest season for many continuous hours, putting them at risk. Tests were conducted at different operating modes and with different numbers of harvester operating units. The results showed that the vibration dose value represents the best way to express the risk of vibration of the harvester driver compared to other indicators. The results also indicated that there is a real threat to the driver's safety, with work continuing for many hours during the day. The vibration dose values during the paddy harvest exceeded the safe values according to this indicator. This requires directing the operators of agricultural machines to reduce the number of consecutive hours of work and convert them into working meals separated by sufficient times of rest.
Keyword: Combine, VDV, vibration, rms, crest factor, exposure

Introduction

Vibration emitted by the agricultural combine harvester during crop harvesting produces unacceptable risk that leads to the degradation of driver health. Most of the laboratory and field investigations conducted on Whole Body Vibration (WBV) assessment used the criteria of RMS acceleration to measure the vibration magnitude. However; the Britain Standard (BS 6841–1978) consider this method of assessment is not valid any more according to the basis of Crest Factor (CF) value of 6. Therefore; the V.D.V. should be used as an alternative variable. In this regard the Britain Standard stated that when the crest factor exceeded 6 or vibration has variable amplitude or the operation show sudden shocks the V.D.V. method should be applied. V.D.V. $m.s^{-1.75}$ is an experimental factor that deal with the vibration magnitude and the time duration where it occurs. The purpose of V.D.V. assessment is to enable the employer as well as the driver to make a valid decision concerning V.D.V. values weather it reached the measure necessary to prevent or to control the exposure of the driver to whole – body vibration WBV . Another use of V.D.V. is to assess the intermittent vibration level over an 8-hours or 16- hours period. Mani *et al* (2011) considered V.D.V. as a good index of the discomfort and magnitude relationship, it is sensitive to pulsation vibration and it used to fined lower magnitude vibration for durations less than 8 hours . While Zeng (2016) study assessed the WBV vibration effect on human body using the metrics of standardized factors R.M.S and A (8). The crest factor (C.F) also used for further analysis, and it is defined as the ratio of the maximum value of prompt peak to R.M.S value. The results showed that when the C.F are higher than 9 the substantial peaks exist and the RMS values does not sufficient to describe the W.BV. It should be noted that the results of this study for x, y, and z of the RMS, peak values, crest factor and VDV of the combine harvester were (0.19, 0.16, 0.31) $m.s^{-2}$, (3.49, 3.14, 18.42) $m.s^{-2}$, (19.58, 17.68, 55.85)$m.s^{-2}$ and (3.5, 3.10, 9.26) $m.s^{-1.75}$ respectively. Larson Dis Cooperation (www.larsondvis.com) considered V.DV as an substitutional estimate of exposure that frequently used to a perfect indication of risk related with shock or peak, The V.D.V is a cumulative amount that rises with time of measurement, The greatest value of V.D.V exp X, VDV exp Y or V.D.V exp Z is the V.D.V .The Directive of Vibration 2002/44/EC determines a caution zone of daily exposure consider to V.D.V equal to or more than 9.2 $m.s^{-1.75}$ which require to do action for controlling vibration hazard, as well as likely health exposure zone 21 $m.s^{-1.75}$ above which operator must not be exposed (EU Good Practice Guide WBV 2006). While the other standards ISO 2631 – 1 and AS 2679. 1 recommended a VDV caution range and probable health exposure range equal to 8.5 and 17 $m.s^{-1.75}$ established on the a 8 h of work. These figures were posted by the Safe Environments agency (Managing property risk, Melbourne 03 9604 0700). Kabir *et al.* (2017) revealed that the VDV values are opposed to rms values in terms of outputs and more sensitive to the shock amplitude peaks the sum of V.D.V did not override the A.L. value of 9.1 in all tested cases, however, it was very low in term of values on smooth roads due to absence of multiple shocks. Servadio and Belfiore (2013) tested the effect of vibration on the health of human by this styles : the caution zone in health guidance, vibration dose value, The fourth exponent to the VDV and using all this ways. It appears clear most of the researchers who attempted to assess and analysis WBV exposure results did not have clear understanding of these aspects and the parameters VDV is often neglected or completely ignored. The research was aimed to determine whether the vibration magnitude in term of VDV emitted by the combine harvester during the different operation of paddy harvesting did reach the dose of danger that must be controlled or exceeded to the dose that should not be exposed to the driver any more.

Material and Methods

The whole body vibration treatments were conducted using the commonly used a wheel crawler German made Class Dominator 68 combine harvester model. The harvester is equipped with full crop processing units which include rice threshing unit and also equipped with 6 cylinders engine located behind the driver cab. The driver cab has been approved as safely and compatible with international standard requirement. The European Good Practice Guide defined the WBV with frequency and amplitude. However, the frequency is define as the oscillating movements in one second and Represented in units hertz (HZ) or cycles per second .The amplitude is define by acceleration with ($m.s^{-2}$). The VD.V. symbolized to the cumulative value of vibration dose, which reported in $m.s^{-1.75}$. The V.D.V. mean the top value from V.D.V. exp X, V.DV exp Y or VDV. exp Z. In this research RMS, daily exposure A(8), VDV assessments were done in four operation modes . These are the routine daily check, transportation on paddy field routs, transportation inside the paddy field and harvesting mode. The operation modes, tests performed and source of vibration tested are presented in table 1.

Table 1 : Operation modes tested

Operation mode	Description	Treatment	Engine	Transmission	Platform	Threshing unit	Separation & cleaning unit	Loading unit
daily routine check			√					
			√			√	√	√
			√	√	√	√	√	√
Transportation on paddy field route			√	√				
			√	√		√	√	√
			√	√	√	√	√	√
Transportation inside paddy field			√	√				
Harvesting			√	√	√	√	√	√

The vibration measuring device (EBBESSD Ei – Calic) was used for measuring the harvester vibration levels in directions of $\dot{x}$, У and $\dot{z}$. The X axis refers to the longitudinal direction (forward to backward motion), the У axis refers to the transverse direction (motion from side to side) while the $\dot{z}$ axis refer to the vertical direction (up and down motion). This device was linked to three channels accelerometer through the inlet socket and the outlet to a PC. The data captured would be processed to the root mean square value r.m.s. in the three mentioned trends. All the parameters accept the routine check parameter have been tested over a pre – determined 50 meters test distance and the data capture duration was only a minute of randomly selected during the implementation of the treatments. The vibration testing program acquisition menu was restored at the engaged computer prior to the beginning of the study and the software options were activated during the implementation of the testing program. A computer program released by the British Health and Safety (HSE) called WBV Calculator was used to calculate the V.D.V and the daily VDV exposures. To determine the severity of the harvester vibration, the results were compared with the VDV caution zone and the likely risk zone which suggested by the International Standard ISO 2631–1 : 1997 . All the vibration assessment steps have been summarized according to ISO 2631–1 and presented in the assessment flow chart shown in figure 1.

Equipment Used

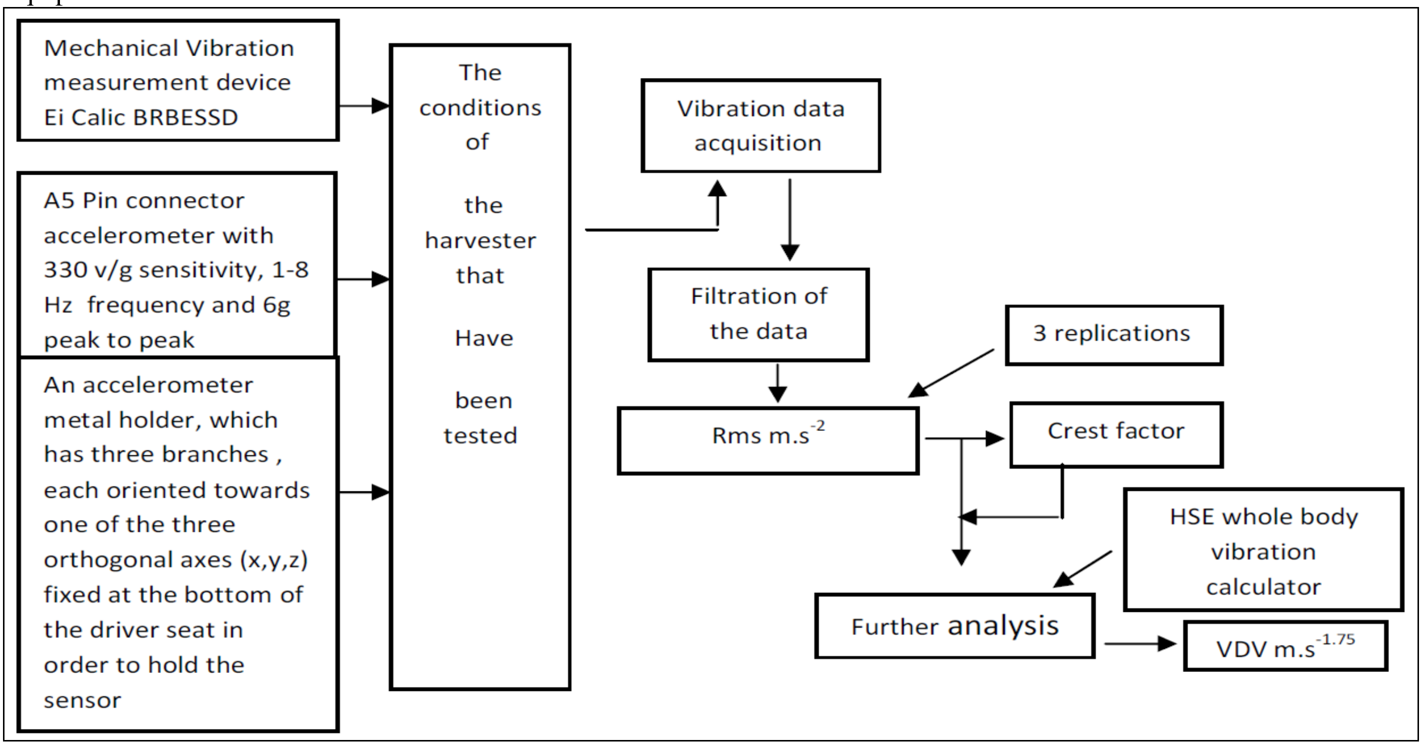

Fig. 1 : Vibration assessment flow chart

RMS values evaluation .

$$a_w=[(1/T)(a_w^2(t)dt)]^{1/2} \quad ...(1)$$

$$a_w = \left[\frac{1}{T} \; a_w^2(t)dt \right]^{1/4} \quad ...(2)$$

$$CF = a_w \text{ Peak} \div a_w \text{ RMS} \quad ...(3)$$

If CF less than 6 then we most only use the RMS, if CF between (6 - 9) then we can use RMS. or VDV, and if CF more than 9 then VDV only used .

V.D.V.s evaluation :

$$VDV = [\int_0^T a_w(t)\, dt]^{1/4} \quad ...(4)$$

Whereas the T is the time duration of the harvester driver and the a_w is the

$$VDV_{SUM} = (VDV^4_X + VDV^4_Y + VDV^4_Z)^{1/4} \quad ...(5)$$

Since the parts of the combine are strictly and simultaneously operating during the harvesting process, therefore , it is possible to calculate the total VDV for all combine units by equation 6.

$$VDV_{TOTAL} = (VDV^4_1 + VDV^4_2 + ... + VDV^4_j)^{1/4} \quad ...(6)$$

Whereas VDV_1 and VDV_2 + ...VDV^4_j are the combined axes VDVs of the harvester units as calculated by equation 5. (British Standard BS 6841 of equation 1).

Result and Discussion

Table 2 demonstrates the whole body vibration WBV results of various operation of the combine harvester during rice harvesting. Before starting to display the results, it must be noted that the results were validated according to the validation table proposed by Marjanen (2010). The frequency weighted RMS acceleration across the tests 1 up to 6 indicate that the vertical direction Ẓ had the greatest values of RMS as compared with the longitudinal (Ẋ axis) and the lateral (У axis) directions except one value of test 2 . These values are within the Exposure Action Value EAV threshold which was stipulated by the Physical Agent (Vibration) Directive : 2002 (PA(V)D) . It is interesting to note that the mentioned RMS values confirm moderate risk which leads to health complications specially when considering the adverse long term effect experienced by the combine driver, Whereas the highest RMS values that approximated or exceeded the Exposure Limit Value ELV levels were at the Ẋ and У axes upon tests 7 and 8 when the combine was in motion in the field or in case of harvest. These values indicated unacceptable risk and must be subject to a comprehensive evaluation because most of the field work time is spent by the driver to perform these two operations. In addition to that, the rice harvesting process needs a long time to accomplished which raises concerns about the drivers safety. Therefore, The results were presented on flow chart fig 2 to find exposure for an 8-hour working day period .It was found that only one value exceeded the ELV, while most of the values were with the EAV threshold and few below EAV. This finding calls for more analysis, since the raw accelerometer signals obtained were accompanied with repeated deep shocks.

The results in table 2 indicate that the peak values behaved similarly to RMS parameter values in relation to the direction of vibration that is the highest peak values were associated with the vertical axis Ẓ. Anyway, the maximum peak values were found when the harvester was moving in the wet harvested field as well as during harvest operation with values equal to 18.42 and 17.8 $m.s^{-2}$ as presented in tests 7 and 8 respectively . The impact of the mentioned values are more than 40 times greater than the RMS impact of the same test at the same direction Which indicate that the vibration is accompanied by repeated spells of deep shocks. This phenomenon was proven by the values of the crest factor for the same data as shown in table 2.

Table 2 showed that the lowest values of the crest factor for all direction tested (X, У, Z) are more than 9, which demonstrate a substantial peak exist. This finding means that RMS value does not adequately describe the WBV emitted by the combine harvester and further analysis toward VDV is required in order to achieve a comprehensive WBV profile. However, the destination of crest factor through the operation sites of this research recorded high rates at harvest and at mobility in motivated wet field Which indicate the presence of large sudden temporary pumps. These crest factor values were well above the suggested threshold by (PA(V) D 2002) above which VDV is considered to be the best measure of exposure to whole body vibration. An observation at table 4 shows that the crest factor correlate with the vibration dose VDV with regard to the vibration configuration in X, У and Z directions. Even though this relationship is negative but it has a very strong effect, the coefficient of determinations is R^2 = - 0.91, 0.70 and 0.83 for Ẋ, У and **Z**. The reason for the negativity of this correlation is the big difference in magnitude between the peek and RMS values.

As stated earlier VDVs have been calculated from the translational accelerations using equation 4 and the results have been reported in table 2. It can be seen that the VDV values in Ẋ, У and **Z** axes at test 1 up to test 6 were dominated by the Ẓ axis, however, this vision has changed in tests 7 and 8. In this situation the VDV values of Ẋ and У axes were greater than the value of Ẓ axis. It also appears from table 2 that some of the VDV dose received by the combine driver exceeded 9.1 $m.s^{-1.75}$ the exposure action values level recommended by (PA (V) D 2002) or 8.5 $m.s^{-1.75}$ caution zone recommended by the International standard (ISO 2631 – 1 : 1997) .

The (AV) values represent total VDV which were determined for daily vibration exposure (8 h) and then the maximum work period should be considered according to the warning limit (9.1 $m.s^{-1.75}$) set by International Standard . AS shown in table 2 and on general all (AV) values exceeded the warning limit (9.1 $m.s^{-1.75}$) while some come close to health exposure zone (15 m . $S^{1.75}$) above which driver must not be exposed.

Table 2 : Vibration results with different indicator

Treat.	**V. Exposure ($m.s^{-2}$)**			**Peak ($m.s^{-2}$)**			**C. Factor**			**V.DV. ($m.s^{-1.75}$)**			**A.V. $m.s^{-1.75}$**
	ẋ	y	ẓ	ẋ	y	ẓ	ẋ	y	ẓ	ẋ	y	ẓ	
T1	0.28	0.39	0.52	**5.32**	**6.67**	**8.20**	19.22	17.15	15.88	2.86	4.03	7.54	9.02
T2	0.22	0.29	0.35	**4.97**	**5.89**	**7.30**	22.67	20.32	20.64	2.21	3.51	5.20	6.65
T3	0.23	0.42	0.54	**5.10**	**6.83**	**9.14**	21.85	15.03	16.78	2.47	4.42	7.80	9.30
T4	0.25	0.44	0.71	**4.99**	**7.40**	**10.40**	19.60	16.88	14.71	2.60	4.55	10.14	11.41
T5	0.33	0.42	0.59	**5.50**	**7.10**	**9.30**	16.91	16.73	15.65	4.42	5.20	8.58	10.96
T6	0.42	0.50	0.59	**6.90**	**7.89**	**9.94**	16.26	15.71	16.73	3.12	5.07	11.83	13.24
T7	1.34	0.81	0.45	**12.80**	**10.70**	**18.42**	9.47	13.15	40.69	6.89	4.81	3.25	9.01
T8	0.94	0.95	0.38	**11.43**	**11.47**	**17.80**	12.16	12.02	46.55	8.06	5.07	2.86	9.94

Treatments		
T1:daily check (Engine only)	T2: daily check (Engine + threshing + separation + loading)	T3: daily check (Engine + all units)
T4: Transportation on paddy field route (Engine + transportation)	T 5: Transportation on paddy field route (Engine + all units except platform)	T6: Transportation on paddy field route (all units without crop harvesting)
T7: Transportation inside paddy field (Engine + transportation)	T8: Harvesting paddy crop (all units)	

References

BSI (1987). measurement and evaluation of human exposure to whole body mechanical vibration and repeated shock.

EU Good Practice Guide HAV (2006). WBV Guide Practice Guide V6. 7g English 070606.doc

Foster, G. and Leeuwen, M. (2007). Managing exposure vibration . Queensland Mining Conference, Townsville.

Kabir, M.S.; Chang, S.O.; Kim, Y.J. and Hong, S.J. (2017). Measurement and evaluation of whole body vibration of agricultural tractor operator. Int J Agric and Bio1 Eng. 10(1).

Mani, R.; Stephen, M.S. and John, S. (2011). The influence of body mass on whole – body vibration : A quad – bike field study. The engineering open access journal 4: 1–9.

Marjanen, Y. (2010). Validation and improvement the ISO 2631–(1997 0 standard method for evaluating discomfort from whole – body vibration in multi – axis environment. A doctoral thesis submitted in partial fulfillment of the requirement for the award of doctor philosophy, Longhborough University

Servadio, P. and Belfiore, N.P. (2013). Influence of tires characteristics and travelling speed on ride vibrations of a modern medium powered tractor. Part 11. Evaluation of the health risk Agric. Eng. Int : CIGR Journal, 15(4): 132–138.

Zeng, X. (2016). Modeling predictors of whole body vibration exposure among Saskatchewan farmers : A key step in low back disorder prevention. M.Sc. Thesis, University of Saskatchewan, Saskatoon. Canada.