RESEARCH ARTICLE OPEN ACCESS

Effect of Hand Transmitted Vibration through Tractor during Ploughing Field

Md. Zakaullah Zaka[1] , Mohd Saad Saleem[2], Abdul Khaliq[3], Mohd Afzal [4]
Department of Mechanical Engineering, University Polytechnic, Integral University, Lucknow , India

Abstract:
In this study, transmission of vibration from the steering wheel of the tractor without any trailer attached with it is discussed. The vibration measurements were carried out on the tractor randomly.An investigation was conducted to determine the transmission of vibration from the steering wheel of the hand tractor to the wrist and upper arm of the operator under actual field conditions during ploughing field. The vibration level on the steering wheel was measured and analyzed and the frequency spectra for the chosen working conditions were obtained. The results indicate that the maximum transmissibility was observed in the first two frequency interval (in Hz) i.e. 1-20 and 20-40, which may harm the operator. The frequency interval was 1-20 (target-wrist), 1-20 (target-upper arm), 20-40 (base-steering), 20-40 (base-steering) and frequency zone was 0.022, 0.3974, 0.2066 and 0.1531 respectively.
Keywords: Lab View, Power spectrum density, Tractor, Vibration.

I. Introduction:

The term 'hand-arm vibration', is frequently used to refer to vibration from power tools, but it does not clearly indicate whether the hand and arm are the origin of the vibration or the limits of its effects. The expression 'local vibration' suggests that the effects are localized near to the point of contact with a source of vibration. While some effect can, by definition, only occur in the fingers or hand, the vibration is transmitted further into the body and the effects it produces there may be of interest. It is therefore more satisfactory to refer to hand transmitted vibration, meaning vibration entering the body through hands .[4].The reviews on the effect of vibration on human health have shown serious evidence of operator ill health that may be attributed to tractor drivers. The frequency range of 2-6 Hz has been observed to be the most harmful for the human operator because resonance occurs within this frequency range [5].The measurement of vibrations transmitted from the steering wheel of the small tractor with a 4-wheel drive to the driver's hands were carried out on the tractor which is randomly chosen from the producer's store-house. The vibration level has been measured at idling and full load. The vibration level on the steering wheel were measured and analyzed and the frequency spectra for the chosen working condition were obtained.[3]. The vibration, which is transmitted from the handle to the hands, arms and shoulders, causes discomfort to the operator and results in early fatigue. It is found that the transmission of vibration from the handle of the tractor to the wrist, elbow and shoulder of the operators under actual field conditions during transportation on the various land, the transmission of vibration were maximum during the Rota-tilling operation. It is also observed that the work related body pain (WRBP) were maximum while transportation on rota-tilling followed by rota-puddling operation. [2]

II. Methodology:

A Lab View code was written to design the instrument for the recording of vibration levels is shown in figure (1). The data acquisition was made possible using tri axial transducer (model no. SEN041F was made by PCB piezoelectronics, NEW YORK, USA; having 10.23 mV/g,10.66mV/g and 10.41Mv/g sensitives in x, y, z direction respectively, the certificate is enclosed as appendix A) that was connected to NI card (Model No. NI9234 made by National instruments) using lead and the card was interfaced with a Acer laptop (specifications P6000 PROCESSOR, 3 GB RAM).The setup was supportive to the sampling rate of 26,400 per second .However the mean values were only recorded .The recorded data was auto stored in text/excel files in the laptop. The items used in the experimental setup are shown in figure (2). Procedure to measure the vibration on tractor steering is very much standardized. Vibration measurement on tractor steering have been performed, vibration are measured along z- axis vertical axis. We were using NI USB-9233 data acquisition device. The USB-9233 consists of two components: an NI 9233 module and aUSB-9162 USB carrier, for vibration measurement, NI USB-9233 connected with personal computer through lead.

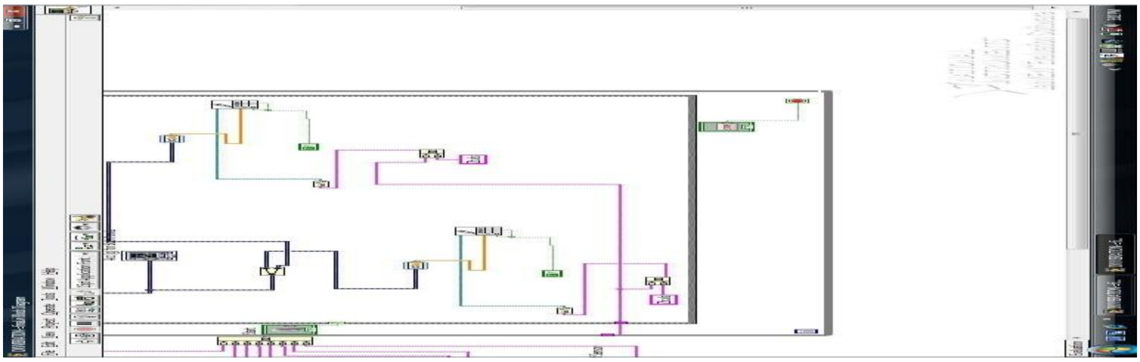

Figure 1. : The Block diagram of LABVIEW code used for the recording of Vibration levels (in g)

Figure 2. : The items used in data acquisition process (Triaxil transducer, Adaptor to hold transducer, data acquisition card and interfacing with Laptop)

Two integrated electronic piezoelectric (IEPE) sensor connected to BNC connector . One of the sensor are attached to steering (z-base) and second one sensor are attached to driver forearm and upperarm (near shoulder) (z-target) ,so we get The collected data was processed and analyzed with LabView TM and by using MATLAB programme for each test . First and foremost subject of the test was given written information about the experiment, which included the purpose of the study. The tractors that were used in experiment was in working condition, tyres of the tractor for the test were of standard size. Tests are carried out on FARMTRAC 50 model on ploughing field which is shown in figure (3).

Figure 3 : a) FARMTRAC 50 model on ploughing field , b)Sensors position on steering and lower arm (wrist), c) Sensors position on steering and upper arm

Farmtrac 50 from Escorts Ltd. is a 4 stroke, direct injection diesel run tractor with a capacity of 2868 cc. The vehicle comprises a mechanical constant mesh gearbox with 8 forward and 2 reverse gears. Farmtrac 50 is equipped with a recirculation ball type, worm and nut with double drop arms steering and also has an option of a

power steering. The tractor is featured with drum (internal expanding shoe) brakes along with a hand operated parking brake. For measuring vibration, the tractors were moving on a specified field with certain speed. The test is carried out on tractor without any trailer attached with it but load attached to it like ploughing equipment. Subjects were considered to be healthy with no signs of musculo-skeletal system disorders. Two sensor were used for measurement of vibration in z direction, first sensor is SEN041F triaxial shear icp accelerometer , this recognized as a z-base sensor ,it is attached to tractor steering of Farmtrac -50 model tractor to measure its vibration at steering ,second sensor used for test is 353B18 SN 140184 ,it is recognized as a target sensor ,this sensor attached to subject forearm and upper arm to measure the vibration transmitted to the hand of the subject.
First sensor attached to DAQ via blue cable at terminal A0-1 and second sensor is attached to DAQ via white cable at terminal AI-1. Figure (4) Shows the screen shot of the LABVIEW code for recording vibration levels in Z- direction.

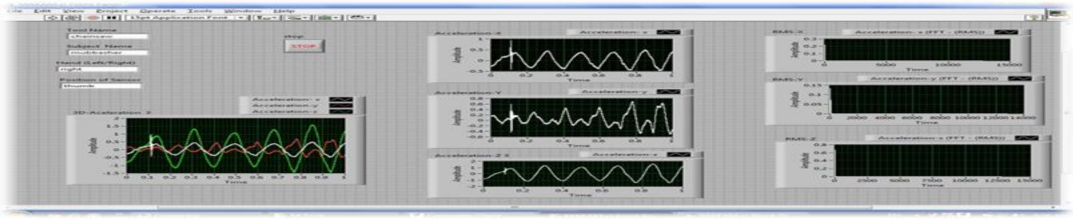

Figure 4: Screen shot of the LABVIEW code for recording vibration levels in Z direction.

III. Results:

Tests were carried out on FARMTRAC 50 model on ploughing field without any trailer attached with it but load attached to it like ploughing equipment. The vibration transmitted to hand through steering of tractor was taken by using Lab View code with the help of laptop. The recorded data was auto stored in text/excel files in the laptop. Table-1 Shows the power spectral density at different frequency zone for z-base on steering.

TABLE-1 : Power spectral density at different frequency zone for z-base on steering.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Base(steering)	1-20	0.1005
2	,,	20-40	0.2066
3	,,	40-60	0.1166
4	,,	60-80	0.0373
5	,,	80-100	0.0060
6	,,	100-120	0.0004
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000
11	,,	200-220	0.0000
12	,,	220-240	0.0000
13	,,	240-260	0.0000
14	,,	260-280	0.0000
15	,,	280-300	0.0000
16	,,	300-320	0.0000
17	,,	320-340	0.0000
18	,,	340-360	0.0000
19	,,	360-380	0.0000
20	,,	380-400	0.0000
21	,,	400-420	0.0000
22	,,	420-440	0.0000
23	,,	440-460	0.0000
24	,,	460-480	0.0000
25	,,	480-500	0.0000

Table-2: Power spectral density at different frequency zone for z-target on wrist.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Target(wrist)	1-20	0.0022
2	,,	20-40	0.0000
3	,,	40-60	0.0000
4	,,	60-80	0.0000
5	,,	80-100	0.0000
6	,,	100-120	0.0000
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000
11	,,	200-220	0.0000
12	,,	220-240	0.0000
13	,,	240-260	0.0000
14	,,	260-280	0.0000
15	,,	280-300	0.0000
16	,,	300-320	0.0000
17	,,	320-340	0.0000
18	,,	340-360	0.0000
19	,,	360-380	0.0000
20	,,	380-400	0.0000
21	,,	400-420	0.0000
22	,,	420-440	0.0000
23	,,	440-460	0.0000
24	,,	460-480	0.0000
25	,,	480-500	0.0000

Table-3. Power spectral density at different frequency zone for z-base on steering.

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Base(steering)	1-20	0.1072
2	,,	20-40	0.1531
3	,,	40-60	0.0470
4	,,	60-80	0.0382
5	,,	80-100	0.0043
6	,,	100-120	0.0003
7	,,	120-140	0.0000
8	,,	140-160	0.0000
9	,,	160-180	0.0000
10	,,	180-200	0.0000
11	,,	200-220	0.0000
12	,,	220-240	0.0000
13	,,	240-260	0.0000
14	,,	260-280	0.0000
15	,,	280-300	0.0000
16	,,	300-320	0.0000
17	,,	320-340	0.0000
18	,,	340-360	0.0000
19	,,	360-380	0.0000
20	,,	380-400	0.0000
21	,,	400-420	0.0000
22	,,	420-440	0.0000
23	,,	440-460	0.0000
24	,,	460-480	0.0000
25	,,	480-500	0.0000

Table-4. Power spectral density at different frequency zone for z-target on upper arm

Serial no.	Sensor position	Frequency zone(Hz)	Power spectral density
1	Target(upperarm)	1-20	0.3974
2	,,	20-40	0.0011
3	,,	40-60	0.0006
4	,,	60-80	0.0005
5	,,	80-100	0.0004

6	,,	100-120	0.0004
7	,,	120-140	0.0004
8	,,	140-160	0.0004
9	,,	160-180	0.0004
10	,,	180-200	0.0004
11	,,	200-220	0.0004
12	,,	220-240	0.0004
13	,,	240-260	0.0004
14	,,	260-280	0.0004
15	,,	280-300	0.0004
16	,,	300-320	0.0004
17	,,	320-340	0.0004
18	,,	340-360	0.0004
19	,,	360-380	0.0004
20	,,	380-400	0.0004
21	,,	400-420	0.0004
22	,,	420-440	0.0004
23	,,	440-460	0.0004
24	,,	460-480	0.0004
25	,,	480-500	0.0004

Table -5: Maximum power spectral density in accordance with the frequency zone (in Hz)

Serial number	**Sensor Position (in Hz)**	**Frequency zone (in Hz)**	**Power spectral density (maximum)**
1.	Base (on steering)	20 – 40	0.2066
2.	Target(wrist)	1 – 20	0.022
3.	Base(on steering)	20 – 40	0.1531
4.	Target (upper arm)	1 – 20	0.3974

IV. Discussion:

The vibration transmitted to hand through steering of tractor was taken by using LabView code with the help of laptop.Table-1 shows the vibration level on steering and Table-2 shows the vibration level on wrist. Likewise, Table-3 and Table-4 shows the vibration level on steering and upper arm. The vibration level on the steering and target point wrist and upper arm has measured and analyzed and the frequency spectra for the chosen working conditions were obtained. The results indicate that the maximum transmissibility was observed in the first two frequency interval (in Hz) i.e. 1-25 and 25-50.the frequency interval was 1-25 (target wrist), 1-25 (target upper arm), 25-50 (base steering), 25-50 (base steering) and frequency zone was 0.022,0.3974,0.2066,0.1531 respectively. Table- 5 shows that the maximum power spectral density in accordance with the frequency zone (in Hz).it seems that the power spectral density is maximum at the target point shoulder i.e. 0.3974 in comparison to the target point wrist i.e.0.022. The vibration transmitted from target point shoulder was more than the target point wrist also it was suggested by [1] that the operators of power tools with frequencies below 25 Hz may experience greater muscles/tissues fatigue and symptoms of musculoskeletal disorder when working with extended arm posture.

V. Conclusion:

The following major conclusions can be drawn from the present investigation:

(1) The frequency zone 1-20 and 20-40 has given the maximum power spectral density.
(2) In the frequency zone 1-20 for target (wrist) and for target (upper arm) has given the power spectral density 0.022 and 0.3974 respectively.
(3) In the frequency zone 20-40 for base (steering) has given the power spectral density 0.1531 and 0.2066.
(4) The frequency zone 1-20 and 20-40 were the most harmful frequency zone for tractor driver because resonance occurs within this frequency zone and also experience greater muscles/tissues fatigue and symptoms of musculo skeletol disorder when working with extended arm posture.

Therefore, the vibration level at the operator's seat needs to be attenuated within acceptable limits in this frequency range. This study helped in understanding the effect of vibration level on tractor driver. The results indicated the value of research work aimed at reducing vibration levels. Ergonomic studies are recommended to determine the vibration response in agricultural production activities.

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