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Experimental investigation on human hand arm vibration in a jack hammer operator – sand floor

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Abstract - Labour forces are subjected to more intensive work conditions in India. It is necessary to determine the safe levels of harshness a human body should be exposed to. This paper focuses on human hand-arm vibration. An experimental investigation is made on Sand hammering workers by measuring the vibration transmission into their body. The measured values are compared with ISO 5349-1:2001 standards. The vibration levels are considerably high and risky. This encourages the use of alternative design for jackhammers.

Key words:

Hand arm Vibration, Human response, Acceleration.

1. INTRODUCTION

This project mostly deals with the study of the human response to vibration from a heavy hand operated tool (Jack hammer in this case) that affects the hand arm system[1,2]. For a better validation, experimental studies were made, based on ISO: 5349-1:2001[3], on a Jack driller operator to study the vibration levels in an actual operation and the values were analysed. Daily exposure to hand-arm vibration over number of years can cause permanent physical damage usually resulting in what is commonly known as white-finger syndrome, carpal tunnel syndrome [4,5], and permanent damages to the joints and muscles of the wrist and/or elbow. White-finger syndrome, in its advanced stages, is characterized by a blanching of the extremities of the fingers which is caused by damage to the arteries and nerves in the soft tissue of the hand. Three main considerations while studying the effects of vibration on the human body [6]: The preservation of working efficiency, the preservation of health or safety ('exposure limit'), the preservation of comfort. The experiments were conducted using a Bosch Jackhammer [7] on a average industrial worker on different operating environments using different operating conditions of the electric hammer. Over exposure to hand-arm vibration may in some cases even lead to neurological damages.

2. EXPERIMENTAL ANALYSIS

The entire procedure was carried out with accordance to the ISO standards [3]. Tests are being conducted on humans and it's necessary to adhere with the standards. The entire study is done on a jackhammer operator. The vibration is to be measured from the Machine, wrist, lower arm and upper arm.The experiment conducted on two different speeds of the jackhammer. The jackhammer was set to the extreme speeds. The accelerometer was taped to the hands of the operator. The experiments were performed on a dry sand floor. The accelerometer was connected to vibration meter which eliminates the need for using a PC.

3. ACCELEROMETERSPECIFICATION [6]:

A PCB-356A44 tri-axial accelerometer is used for measuring the amplitude of vibration. It is capable of measuring acceleration values from the three direction of the source. The accelerometer readings were shown by a VM 30 vibration meter.

Table 1: Accelerometer specification.

Sensitivity	(±10%) 50 mV/g (5.1 mV/(m/s²))
Measurement Range	±100 g pk (±981 m/s² pk)

Broadband Resolution	0.0006 g rms (.006 m/s² rms)
Frequency Range	(+/-5%) 0.7 to 7000 Hz
Electrical Connector	1/4-28 4-Pin

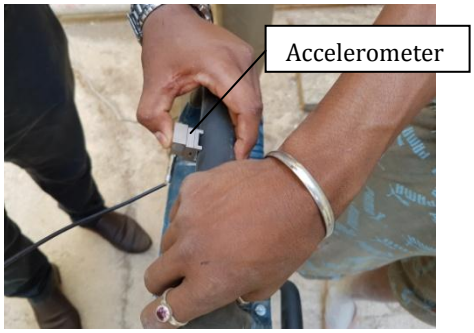


Fig.1 accelerometer being held to the hammer handle.

4. JACKHAMMERSPECIFICATION[7]:

A Bosch 11245EVS combinational hammer is used for testing.

Table 2 : Jackhammer specification.

Amperage	14.0
Chuck design	Keyless
Chuck size	SDS-Max
Length	23.5''
Material	Metal, Plastic
No load BPM	1100-2500
No load RPM	120-250

5. HUMAN OPERATOR DETAILS:

The table indicating the properties of human hand which are taken from the ILO standards is shown below

Table 3: Properties of Human hand

	Mass (kg)
Fingers to Wrist	0.65%M
Lower arm	1.62%M
Upper arm	2.71%M
Shoulder	-

Total mass of the worker which we measured = 88.5kg

The forcing function which acted on the worker from the Jack hammer is given by,

$$\mathbf{F = mj*a*(sin\omega t)}$$

Where,

$$\omega = 2\pi N/ 60 \text{ (rad/s)}$$

6.ISO 5349-1:2001:

When an evaluation of exposure to hand-transmitted vibration is carried out in accordance with ISO 5349, the following information should be reported: —

- the subject of the exposure evaluation
- the operations causing exposures to vibration
- the power tools, inserted tools and/or workplaces involved
- the location and orientation of the transducers
- the individual root-mean-square, single-axis frequency-weighted acceleration measured
- the vibration total value for each operation
- the total daily duration for each operation
- the daily vibration exposure.

7. QUANTITY TO BE MEASURED:

The primary quantity used to describe the magnitude of the vibration shall be the root-mean-square (r.m.s.) frequency-weighted acceleration expressed in metres per second squared (m/s2).

8. MULTI-AXIS VIBRATION:

- In most power tools the vibration entering the hand contains contributions from all three measurement directions.
- It is assumed that vibration in each of the three directions is equally detrimental. Measurements should therefore be made for all three directions.
- The frequency-weighted r.m.s. acceleration values for the x-, y- and z-axes, shall be reported separately

9. MEASUREMENT AXES:

For HAV the triaxial sum of the acceleration experienced by the worker in the three axes (x, y and z) as shown in Figure, is used in calculating

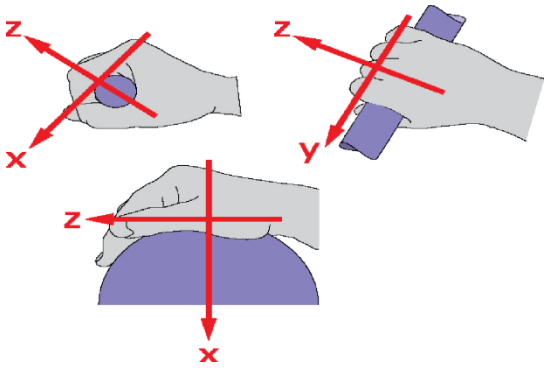


Fig. 2 Measurement axes

10.MEASUREMENT AND RESULTS:

The measurement of vibration amplitude is done using a PCB accelerometer and the readings are obtained using a vibration meter (VM-30)

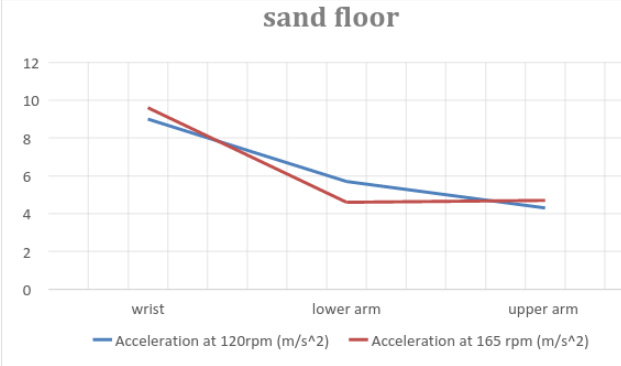
Fig.3 Vibration meter

Table 4: measured readings

S.NO	ACCELEROMETER POSITION	ACCELERATION : (m/s2)	
		WORKING CONDITION: NORMAL FLOOR	
		SPEED : 120 rpm	SPEED : 165 rpm
1	WRIST	8.56	9.142
2	LOWER ARM	4.898	4.205
3	UPPER ARM	3.701	3.926

The real time data (acceleration levels) are measured using tri-axial accelerometer for 10sec time period.

11. ANALYSIS:



Graph : 1 Experimental analysis (acceleration values) of Sand floor under different speeds

The graph 1 shows the acceleration levels at each part of the hand (i.e., from wrist to upper arm via lower arm) when the breaker is operated on Normal sand floor at two different operating speeds namely 120rpm and 165rpm.It can easily be inferred from the graph that the acceleration level continuously decreases from wrist to upper arm and also its effect decreases if speed I decreased and vice versa. The decrease in value is due to the losses at joints and damping characteristics of human muscle. The line shows the distribution (range)of acceleration levels in the lower arm and not at the single point. It indicates how the acceleration level is continuously decreasing in the lower arm from the wrist.

12. CONCLUSION

Thus the vibration induced in the human hand arm system during a jackhammer operation is measured effectively. The human risk involved in high vibration[8] environment is emphasised and evaluated by suitable methods. And precautions and necessary counter measures must made to protect worker health avoiding the harmful effects. Prolonged exposure to these kind of situations might lead to irreversible damages to the worker, physiologically and psychologically[9,10].

Prevention should include using appropriate machines to handle rock hardness, rock uni-axial compressive strength and density, and seat improvement using ergonomic approaches such as including a suspension system and appropriate damping methods. In conclusion, the present study demonstrates that all drill operators in iron ore mines in India are highly exposed to Hand Arm Vibrations exposure and consequently to an increased risk of health problems.

Reference:

1. Alan Hedge, Human Vibration, Cornell University ,2013.
2. Brüel&Kjær ,Human Vibration,1985
3. *ISO:5349-1:2001* -Indian Standard, mechanical vibration — measurement and evaluation of human exposure to hand transmitted vibration - 2001
4. http://www.hse.gov.uk/vibration/hav/casestudies/mhav-carlwest.htm
5. G Wieslander, D Norbäck, C J Göthe, and L Juhlin, Carpal tunnel syndrome (CTS) and exposure to vibration, repetitive wrist movements, and heavy manual work: a case-referent study, British journal of industrial medicine vol.46(1) pp:43-47, 1989.
6. http://www.pcb.com/products.aspx?m=356A44
7. https://www.boschtools.com/us/en/boschtools-ocs/sds-max-hammers-11245evs-27664-p/
8. Mirbod SM, Iwata H, Proposal for hand-arm vibration exposure limits adopted for Japanese workers operating hand-held vibration tools, International Archives of Occupational and Environmental Healthvol.69(6) pp:418-422, 1997.
9. Jessica Korning, Fabrice B. R. ParmentierPsychological effects of combined noise and whole-body vibration: A review and avenues for future research, Proceedings of the Institution of Mechanical Engineers Part D Journal of Automobile Engineering vol.224 pp:10,2010.
10. N.A. Azmira, M.I. Ghazalia, M.N. Yahyaa, M.H. Alib, , J.I. Song, Effect of hand arm vibration on the development of vibration induced disorder among grass cutter workers, 2nd International Materials, Industrial, and Manufacturing Engineering Conference,2015.