

Vibration Transmissibility Characteristics of Human Hand Arm System Under Different Posture Using Drill Machine

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Abstract---The drill machine operators are subjected to extreme vibrations due to the vibrations of its motor, improper structural design of the workplace, improper body posture of operator and the bad working positions conditions. The literature review reveals that the vibrations are most hazardous to the health if it exceeds the limit. In this paper the experiments were conducted to measure the magnitude of the vibrations acting on the operator during drilling operation at various position. Experimental values of accelerations and frequencies which are beyond permissible limits according to the literature confirm that vibration certainly affects health of the machine operator.

Key Words: Health, machine operator, Vibration

I. INTRODUCTION

Hand-arm vibration (HAV) is vibration transmitted to the hand and arm during the operation of hand-held power tools and hand-guided equipment, or holding materials being processed by machines. Hand-arm vibration is commonly experienced by workers who regularly use tools such as jackhammers, chainsaws, grinders, drills, riveters and impact wrenches.

Mr. S. K. Chand has done an experimentation to compare the transmissibility from 'handle to wrist' and handle to elbow'. In this study, the transmission of z-axis and y-axis handle vibration to the wrist and elbow of the human hand and arm are characterized in the laboratory for the horizontal and vertical direction [1]

Nidhi Singh has done the study which was involved determination of transmission of vibration which transmitted to tractor driver's hands from steering wheel. An investigation was conducted to determine the transmission of vibration from the steering system to the wrist, elbow & shoulder under the different conditions i.e., farm field, tar-macadam road & bricks road [2] Mr. Sudhir has carried out a review of various literatures available on segmental vibration and its effect on human being. [3]

These vibrations which are transmitted into hand causes various effect on the hand such as finger whitening, hand grip loss etc. Hence it is necessary to measure the vibration transmitted into hand in an excess limit. In this project we measured the vibration transmitted into human body by considering various body posture such as Front, inclined, vertically upwards, vertically downwards. Then afterward we would suggest the most suitable position for doing the particular task. These will be helpful for further implementation in future with feedback control system for controlling vibration while it crosses the maximum limit. Apart from these would also consider different material for drilling.

This research will be helpful for the employees who are continuously dealing with vibratory equipment's and with

recommendations of the limit vibration they can avoid vibration up to some extent. The main purpose behind this research is to provide vibrations working area for healthy environment.

II. EXPERIMENTAL SETUP

Figure No. 1 shows the actual set for measurement of vibration through drilling machine to the hand. In simplest form it consists of following major components:

- 1) Fast Fourier Analyzer
- 2) Load Cell ckt
- 3) Personal Computer
- 4) Drill machine

A. Preparation for the setup

For the setup frame we have used various size of the 'L' angle and square bars. It is then welded to take different angle variations. The frame is then assembled.

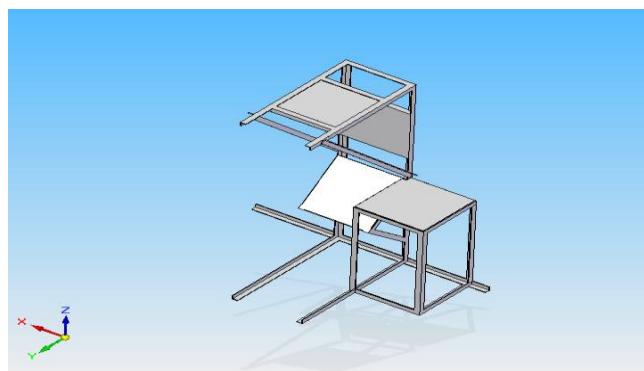


Fig 1 set up diagram for vibration measurement

For the measurement the wooden block is drilled and wooden plank is attached to it by means of the nut and the bolts arrangement. The final assembled wooden block is then bolted to the frame. Now for the measurement of the applied

force we attached a load cell to the work piece by using the nuts and bolts.

B. Specifications of various components were being used

a. Fast Fourier Transform analyzer

For the measurement of the vibration transmitted through drilling machine to the hand we have used standard digital vibrometer with high accuracy and frequency range. The figure 2 shows the vibrometer.

b. Specification of FFT analyzer

Power	<15 VA	
External AC power supply	Voltage	100 to 240 VAC
	Frequency	47 to 63 Hz
DC	Range	10 V to 28V
No of Channel	Four	
Make	Oros	
Accelerometer	Triaxial, piezoelectric base	

c. Hand held Drilled machine

The hand held drilling machine is one of the most widely used machine for the industrial as well as commercial used. Hence we have been considering drilling machine for the measurement of vibration as a part of vibratory machine. In order to get different reading for different handle diameter we have used.

d. Technical Parameters

- . Rated Voltage: 220v~
- . Rated Frequency: 50Hz
- . Max Diameter: F13mm
- . No-Load Speed:3000rpm
- . Rated Input Power: 810W
- . Bosch electric hand drill

e. Spiral Drill Bit for wood

Made of high-speed steel, milled with cylindrical shank, running at right-side rotation.

- . Sharpening angle 118°.
- . Dia -6mm
- . Length-110mm

III. METHODS AND PROCEDURE FOR MEASUREMENT HAND-ARM VIBRATION MEASUREMENT

A complete assessment of exposure to vibration requires the measurement of vibration acceleration in meters per second squared (m/s^2). Vibration exposure direction is also important and is measured in a well-defined direction. Vibration frequencies and duration of exposure are also determined. How hard a person grips a tool affects the amount of vibrational energy entering the hands; therefore, hand-grip force is another important factor in the exposure assessment. Measuring acceleration can also give information about velocity and amplitude of vibration. The degree of harm is related to the magnitude of acceleration.

A. Experimental Design

Each subject was required to drill the wood at four work positions. Duration of operation has been maintained constant for all subject (10 sec). The size of the work piece is 10 x 10 cm. Thickness of the work piece is 3cm. Each subject was asked to drill the work piece using a 1.5 kg electric drill (Bosch GBM 450 RE Professional Rotary Drill) was fitted with a steel rod bit 11 cm long and 6 mm in diameter) in an upright standing position. Subjects were given a maximum 10 seconds for each operation. There were four experiments taken for each subjects: Experiment 1 was drilling using bench drill for 10 seconds on front position, experiment 2 was drilling using bench drill for 10 seconds on vertically downward position, experiment 3 was drilling using bench drill for 10 seconds on vertically upward position and experiment 4 was drilling using bench drill for 10 seconds on inclined position.

B. Subjects (Human Being) used for hand-arm vibration analysis: -

Three healthy male volunteers are participated in the study. The subjects have no experience or any history or previous injury in shoulder or arm. The subjects were between the ages of 22 and 27 to match the age range of the target working population. Height and weight of each subject were measured.

All subjects were thoroughly informed of the experimental procedure and gave consent prior to participation. Subject demographic were showed in fig.

Table No. 1 Anthropometric of test subjects

Subject	Body Posture		
	Weight (Kg)	Height (Cm)	Arm Length (Cm)
A (Sham)	58	165	72
B (Vishwajeet)	68	174	74
C (Prashant)	60	163	71

C. Procedure

Laboratory experiments were performed to measure vibration transmitted to the wrist and elbow of the dominant right hand and arm of six adult male subjects in the standing position, while grasping an impact drilling machine with 6.5 mm drill subject to z-axis and y-axis vibration on a wooden plank.

The experiments were conducted with P-1 vertically downward direction, P-2 vertically upward position, P-3 inclined position and P-4 front position. The experimental set up is described in Figure 1. Various physical dimensions of the hand-arm of the subjects were measured. The mean of these dimensions together with the subject weight, height, age

In this study the four subjects were exposed to random hand arm vibration during drilling operation. The tri-axial accelerometers (PCB PIEZOTRONICS) are placed on the handle and wrist in order to measure the acceleration at the respective points. The vibration signals from the accelerometers were conveyed to the signal conditioner (ICP SENSOR SIGNAL CONDITIONER 480B21) and then it is

attached to the human vibration meter (FOUR CHANNELS SOUND & VIBRATIONLEVEL METER & ANALYSER).

Each subject was exposed to random vibration magnitudes over the frequency range 1 to 1000 Hz in two different postures as described earlier.

For the measurements we have considered the following positions

- 1) Inclined Position P3
- 2) Front Position P4
- 3) Vertically Upward Position P2
- 4) Vertically Downward Position P1

IV. RESULT AND DISCUSSION

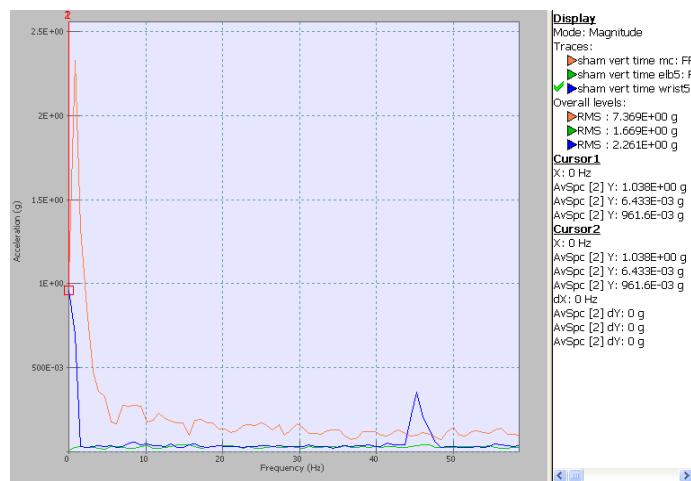


Fig 3. Plot of acceleration vs frequency taken while performing drilling for 10 sec. with applied force of 5.6 kg.

The experimental analysis has been carried on different subject of different body posture at different working positions. In this the readings were obtained at two different points such as machine and wrist. On the basis of the corresponding graphs we have obtained the readings and further these readings are to be analyzed to decide the most suitable position for performing the drilling operations on different materials.

A. Transmissibility

Transmissibility function on wrist is expressed as:

$$T(f) = a_{\text{wrist}}(f)/a_{\text{handle}}(f)$$

Where
 $T(f)$ -Handle to wrist transmissibility, $a(f)$ -wrist acceleration, $a_{\text{handle}}(f)$ – handle acceleration respectively.

B. Result for subjects

Each subject was exposed to random vibration magnitudes over the frequency range 1 to 1000 Hz in two different postures. Following graphs shows the transmission of vibration (i.e. transmissibility) from handle to wrist at four different postures along x-axis. The first resonance peak is observed at a frequency around 92 Hz and second resonance peak is observed at 156 Hz at all position on wrist.

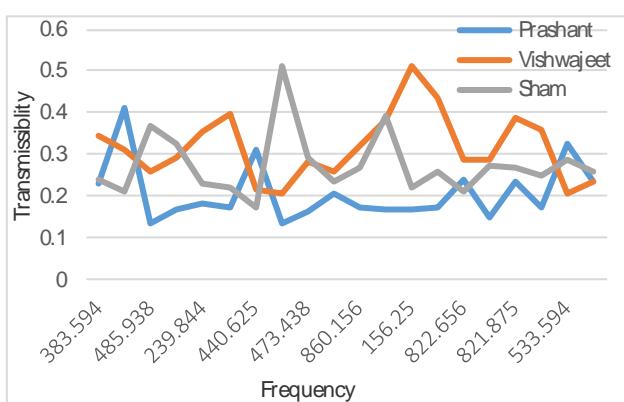


Fig 3(a). Transmissibility from handle to wrist for inclined position along x-axis

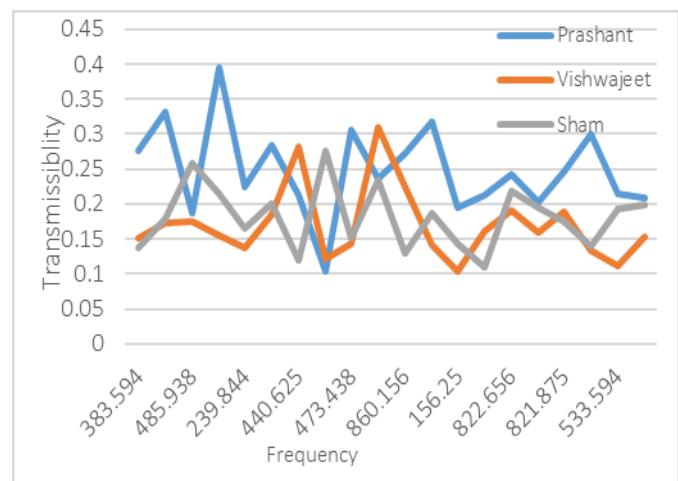


Fig 3(b). Transmissibility from handle to wrist for vertically downward position along x-axis

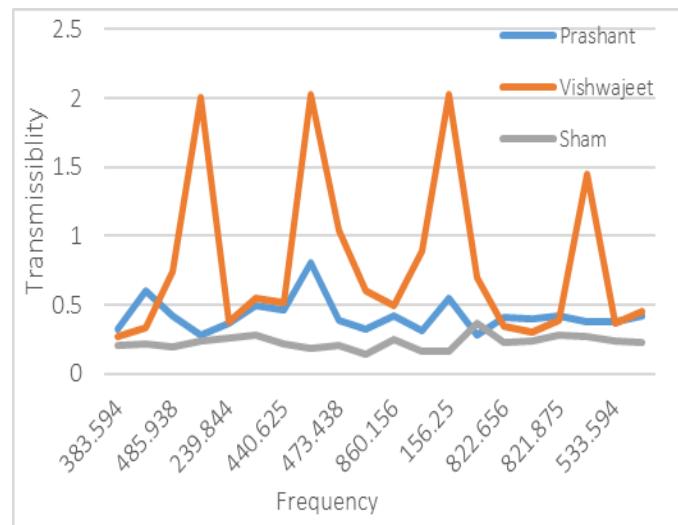


Fig 3(c). Transmissibility from handle to wrist for front position along x-axis

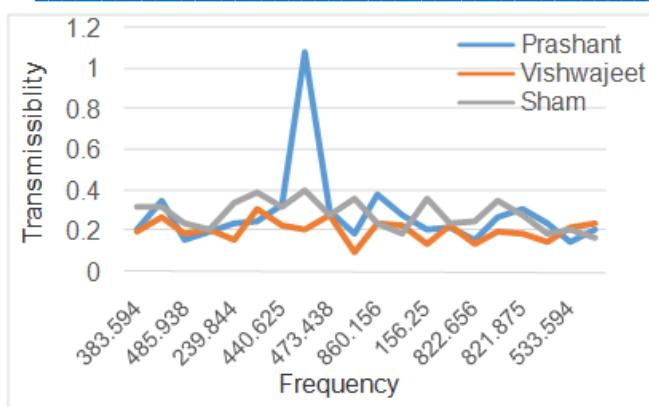


Fig 3(d). Transmissibility from handle to wrist for vertically upward position along x-axis

Following graphs shows the transmission of vibration (i.e. transmissibility) from handle to wrist at four different postures along y-axis. The first resonance peak is observed at a frequency around 92 Hz and second resonance peak is observed at 156 Hz at all position on wrist.

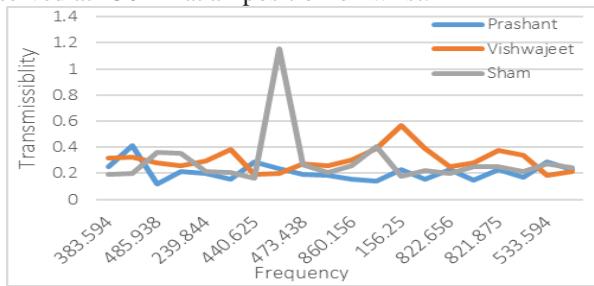


Fig 3. Transmissibility from handle to wrist for inclined position along y-axis

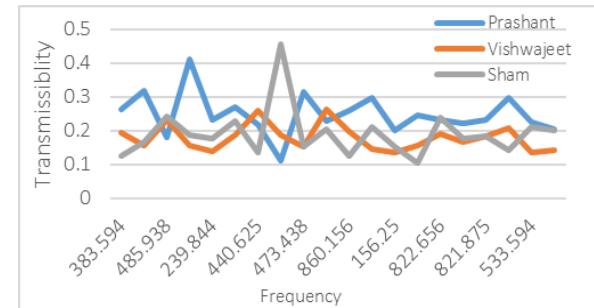


Fig 3. Transmissibility from handle to wrist for vertically downward position along y-axis

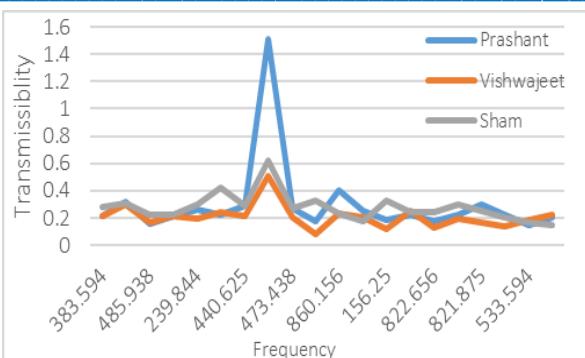


Fig 3. Transmissibility from handle to wrist for vertically upward position along y-axis

Following graphs shows the transmission of vibration (i.e. transmissibility) from handle to wrist at four different postures along z-axis. The first resonance peak is observed at a frequency around 92 Hz and second resonance peak is observed at 156 Hz at all position on wrist.

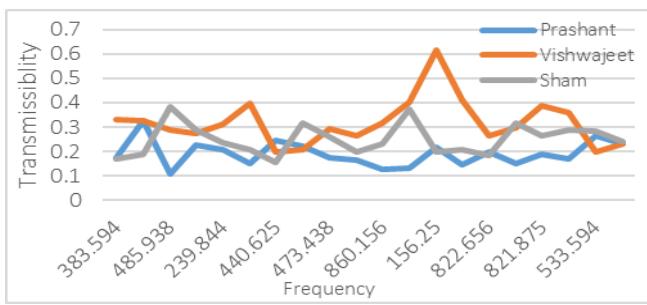


Fig 3. Transmissibility from handle to wrist for inclined position along z-axis

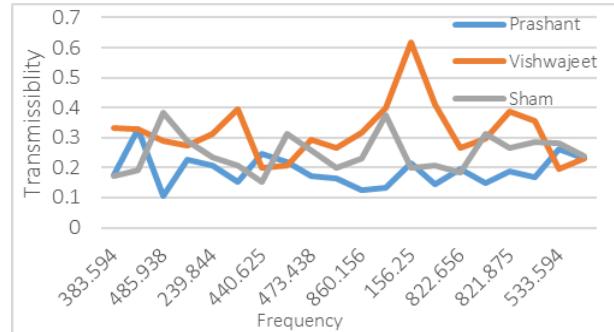


Fig 3. Transmissibility from handle to wrist for vertically downward position along z-axis

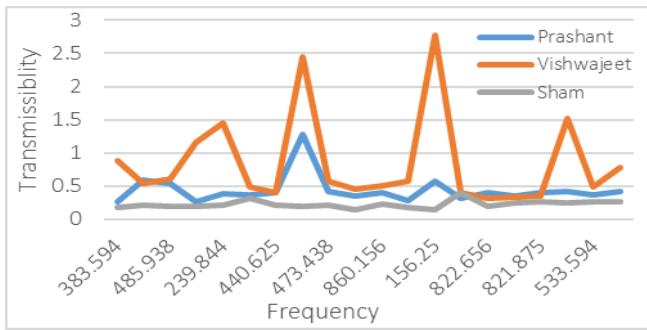


Fig 3. Transmissibility from handle to wrist for front position along z-axis

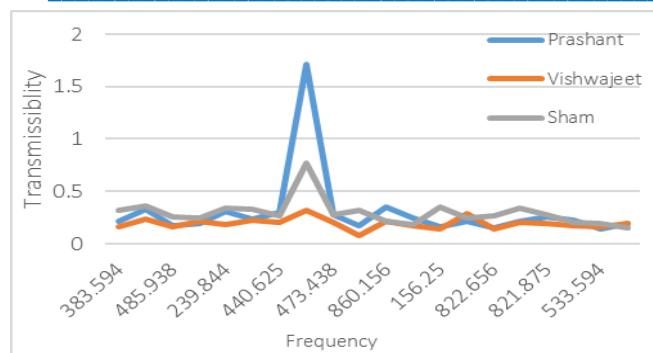


Fig 3. Transmissibility from handle to wrist for vertically upward position along z-axis

From Figure 3(a) it is clear that the resonance peaks are observed at 92 Hz and 156 Hz as above. The transmissibility at wrist is 0.5 on wooden plank for subject A and B, whereas the for subject C the transmissibility is 0.4 inclined position. From Figure 3(b) it is clear that the resonance peaks are observed at 92 Hz and 156 Hz as above. The transmissibility at wrist is 0.3 on wooden plank for subject A and B, whereas the for subject C the transmissibility is 0.4 inclined position.

Conclusions: -

In this paper various human being with different body posture were subjected to drilling operation at different and following conclusion were drawn.

- 1) It was found that the transmission of the intensity of the vibration is minimum at the body posture having the 45-degree inclination.
- 2) Apart from this it was found that among the four location point i.e. finger, wrist, forearm and the arm highest vibration transmitted at finger point.
- 3) As well as lowest vibration transmitted at the arm location point.
- 4) At the same experiment we have observed that at one stage subject cannot sustain vibration to be transmitted into his body. We can also conclude that for any particular operation level of the vibration that human being can sustain cannot predefined and it totally depend upon individual factors such as weight, height, push force, capability of individual for the same operation.

References: -

- [1] S.K. Chand, P.P. Chalotra, Prakash Kumar, V.H. Saran, "Modal Analysis and Vibration Transmissibility Characteristics of Human Hand Arm System Under Different Posture Using Impact Drill Machine" MIT International Journal of Mechanical Engineering, Vol. 3, No. 1, Jan. 2013, pp. 43–50 ISSN No. 2230–7680 © MIT Publications
- [2] Nidhi Singh, Mohd Farhan Zafar, Taufeeque Hasan "Analysis of Hand Transmitted Vibration to Tractor Driver through Steering" 2nd International Conference on Emerging Trends in Engineering & Technology, April12, 13, 2013 College of Engineering, Teerthanker Mahaveer University.
- [3] Dr. Suresh Gulabrao Patil, Sudhir Vinayakrao. Deshmukh, "A Review of Influence of Hand Transmitted Vibration On

Health: Due to Hand Held Power Tools" International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 7, September – 2012 ISSN: 2278-0181

- [4] Anderson J. S., 1978. Measurement of the energy dissipated in the hand and arm whilst using vibratory tools. Applied Acoustics 11, 219–224.
- [5] Bendat, J. S., Piersol, A.G., 1986. Random Data-Analysis and Measurement Procedures. Wiley, New York.
- [6] Boileau, P. E Wu, X., Rakheja, S., 1998. Definition of a range of idealized values to characterize seated body biodynamic response under vertical vibration. Journal of Sound and Vibration 215 (4), 841–862.
- [7] Bovenzi, M., Hulshof, C.T.J., 1998. An updated review of epidemiologic studies on the relationship between exposure to whole -body vibration and low back pain. Journal of Sound and Vibration 215 (4), 595–611.
- [8] Burstroö M, L., 1990. Measurement of the mechanical energy absorption in the hand and arm whilst using vibrating tools. Journal of Low Frequency, Noise and Vibration Control 9, 1–14
- [9] Burstroö M, L., Lundstro M, R., 1988. Mechanical energy absorption in human hand-arm exposed to sinusoidal vibration. International Archives of Occupational and Environmental Health 61, 213–216.
- [10] www.elsevier.com, www.jbiomech.com