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Vibration Effect on Health of Automobile Rider

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Abstract
Evaluation of human exposure whole-bodyvibration and shock can be carried out in a various ways. The most common used standards for predicting discomfort are BS 6841 and ISO 2631 which offer different frequency weightings and multiplying factors to allow for different sensitivity of the body in different axes. For analysis methods based on acceleration, vibration dose value gives the highest correlations between vibration magnitude and discomfort. In the case study, in order to evaluate vibration characteristics of a two wheeler rider, vibration signals were measured while driving with different speeds and different road surfaces. Root-mean-square values and Vibration dose values of accelerations and frequencies which are beyond permissible limits according to the literature confirm that vibration certainly affects health of the rider.
Key words*:* Crest Factor, Accelerator with FFT method, DIC technique

I. Introduction

Due to economic reasons many people used two wheeler vehicles for their transportation. The vibration is common in most of the vehicle and it is more in the two wheeler vehicle because of its dynamic nature. Vibration energy waves transferred into the body of the rider are transmitted through the body tissues, organs and systems of the individual causing various effects on the structures within the body before it is dampened and dissipated The vehicle vibration produces physiological effect on humans. The evidence suggest that short time exposure to vibration causes small physiological effects such as increase in heart rate, increase in muscle tension long term exposure to vibration causes effects such as disk to spine & effects on digestive system. The health problems are also increasing and it is essential to identify whether there is any relation between the health problems of the driver.

Vibration within the frequency range up to 12 Hz Affects the whole human organs, while the vibrations above 12 Hz will have a local effect. Low frequencies (4-6 Hz) cyclic motions like those caused by tires rolling over an uneven road can put the body into resonance. Just one hour of seated vibration exposure can cause muscle fatigue and make a user more susceptible to back injury.

Currently, there are two main standards for evaluating vibration with respect to the human responses to whole body vibration; British Standard BS 6841 (1987) and International Standard ISO 2631 (1997). BS 6841 considers a frequency range of 0.5-80 Hz . This standard recommendsthe measurement of four axes of vibration on the seat (fore-aft, lateral and vertical vibration on the seat surface and fore-aft vibration at the backrest) and combining these in an evaluation procedure before assessing the vibration severity. ISO 2631 suggests that vibration is measured in the three translational axes on the seat pan but only the axis with the most severe vibration is used to assess vibration severity.Therefore it is necessary to evaluate the influence of vibration to the human body and to make up appropriate guidelines for the two wheeler design and selection parts. The intensity of these harmful vibrations is reduced by providing a standard front and rear suspension.

II. Literature Review

Stephan Milosavljevic et al. [1] examined the whole body vibration was measured in 12 farmers during their daily use of all-terrain vehicles (ATVs). The vibrations were measured in accordance with the ISO 2631-1 guidelines for whole body vibration. All those who participated in the experiment were asked to ride their ATV for around 20 min on a typical daily work route of their choice with helmet mounted on their head. The farmers asked to ride when each farmer was sitting on the seat pad containing a tri-axial accelerometer. The exposure vibration data were digitally stored in a 6 channel data logger. Filtering of Vikas Kumara, et al. [6] studied the vibration dose Value (VDV) has been recorded for the driver as well as the pillion of two wheeler vehicle for the different road profile having speed breakers, at different speed. The methodology adopted from the International Organization for Standardization (ISO) guidelines for whole body vibration (WBV) exposure having frequency ranges from 0 to 100 Hz. VDV of six healthy male subjects was recorded through the Human Vibration meter via seat-pad tri-axial accelerometers for two minutes' drive and psychophysical response were measured with the help of Borg CR10 scale. The Time to reach 15 VDV and comfort decreases with the increase in vehicle speed and speed breaker's height, for both driver and pillion. Pillion feels more discomfort with the increase in vehicle speed and speed breaker's height when compared with driver.

Hsieh-Ching Chen etal. [7] This study compares the predicted health risks of motorcycle riders according to ISO 2631-1 and ISO 2631-5 standards. Experimental data suggest that the vibration dose value of ISO 2631-1 and daily dose of equivalent static compression stress of ISO 2631-5 have roughly equivalent boundaries for probable health effects. M K Naidu [8] Vertical dynamic response of the TWV has been found when the vehicle is moving at 45 kmph on random road surface. Damping ratios and natural frequencies are obtained using Eigen value analysis. Ride analysis has been carried out in the frequency domain by performing the spectrum analysis using MATLAB/Simulink. Min-Soo PARK this study presents experimental research evaluation of the vibration exposure for the health risk prediction during vehicle operation. The vibration measurements were carried out on a recreational vehicle and two types of agricultural tractors. The vibration levels were measured for different surfaces and vehicle speed conditions. However, the speed change did not appear to affect the vibration dose variation while driving a vehicle on the highway and road. Finally, the health effect index of ISO2631-5:2004 are almost the same as assessment of health effect by ISO2631-1:1997. vibration data and weighted accelerations, VDV calculations were done with the help of Lab View software. The questionnaire survey method was used, whether the participants had suffered with low back pain, neck back or neck pain within the past 7 days or within past 12 months and concluded Low back pain was the most usual sicknesses for both 7-day (50%) and 12-month (67%), followed by the neck (17% and 42%) and the upper back (17% and 25%), respectively.

Rebecca Wolfgang , et al. [2]studied the haul truck drivers at surface mines are exposed to whole-body vibration for extended periods. Thirty-two whole-body vibration measurements were gathered from haul trucks under a range of normal operating conditions. Measurements taken from 30 of the 32 trucks fell within the health guidance caution zone defined by ISO2631-1 for an 8 h daily.

Ornwipa Thamsuwan , et al. [3] examined whether differences exist in WBV exposures between two buses commonly used in long urban commuter routes: a high-floor coach and a low-floor city bus. Each bus wasdriven over a standardized test route which included four road types. On average, the seats only attenuated 10% of the floor transmitted vibration and amplified the vibration exposures on the speed humps. Due to the low vibration attenuation performance of the bus driver's seat, evaluating different types of seats and seat suspensions may be merited.

Jaimon Dennis Quadros, et al. [4] analyzed and obtain the idealized operating conditions of the human body. The analysis has shown that for the given vehicle and human body, the idealized operating speed for HERO HONDA SPLENDOR vehicle on the terrain of specified amplitude at given input is found to be 49.66 km/hr.

Gourav.p.sinha, p.s.bajaj [5] examined about the practical measurement of vibration occurring on two wheeler vehicle which is very dangerous when it is transmitted to human body through thigh, footrest, seat &handle. So finding the level of vibration occurring in vehicle will be helpful and they can take some steps to reduce it. In this paper they will come to know that every aspect of riding vehicle in smooth road and uneven road from vibration point of view.

III. Methods For Measurement Of Vibration Andanalysis

The principal measurement and analysis procedure for evaluating health and comfort from vibration exposure are 1] Crest Factor 2] Frequency weighted r.m.s. and 3] Frequency weighted vibration dose value (VDV). These are the most widely used methods for producing results from vibration measurements. Both methods use same filters (i.e. weighting curves) to process the acceleration data and multiplying factors for emphasising each axis. The difference is that the r.m.s. method has second power averaging while VDV uses fourth power without averaging duration. Thus VDV emphasises more shocks than the r.m.s. method. Additionally BS 6841 introduced ar.m.q. method, which is similar to the r.m.s. method, but using fourth power averaging.

A. Crest Factor

The crest factor (CF) is a dimensionless quantity defined as the ratio of the peak acceleration to the r.m.s acceleration. The lowest possible crest factor is 1, which occurs for a square wave; a sine wave has a crest factor of 1.4. If any signals contained a single instantaneous shock, then the CF would increase, but the r.m.s. might not be substantially affected. The Value of CF indicates whether r.m.s. or Vibration dose value (VDV) is appropriate for the assessment of whole body vibration. The CF threshold is not universally agreed upon, BS 6841 (1987) and ISO-2631 standards define a CF value of 6 and 9 to designate when r.m.s. method become inferior to VDV method.

B. Root Mean Square (r.m.s.)

The r.m.s method calculates the acceleration value by the square root of mean value obtained from the integration of the squared value of the signal. For the signal containing shocks, the r.m.s rapidly increases during each of these events, but also decays as the averaging time increases. The weighted r.m.s acceleration is expressed in ms^{-2} for translational vibration as follows

$$a_w(T) = \left(\frac{1}{T} \int_o^T a_w^{\ 2}(t)dt \right)^{\frac{1}{2}}$$

Where a_w (T) weighted acceleration time history and T is duration of measurement. [6]

C. Vibration Dose Value (VDV):

Vibration Dose value shows a fourth power relationship between vibration magnitude and dose value of vibration which affects the health as well as comfort of human beings. VDV always accumulates for the vibration exposure and does not decay during periods of low value of vibration magnitude. As recommended by the ISO 2631 standard, daily vibration dose value (VDV) usually causes severe discomfort and health related problems. VDV has calculated as follows:

$$VDV = \left[\int_{t=0}^{t=T} a_w^{\ 4}(t)dt \right]^{1/4}$$

Where a_w(T)weighted acceleration time history and T is duration of the measurement.[6]

IV. Different Techniques To Measure The Vibrationby Experimentally Are As Follow

- Optical method
- Ultrasonic method
- Interferometer method
- Accelerator with FFT method

A. Optical Method:

The availability of high speed digital cameras has enabled three-dimensional (3D) vibration measurement by stereography and digital image correlation (DIC). The 3D DIC technique provides non-contact full-field measurements on complex surfaces whereas conventional modal testing methods employ point-wise frequency response functions. It is proposed to identify the modal properties by utilizing the domain-wise responses captured by a DIC system. This idea will be illustrated by a case study in the form a car bonnet of 3D irregular shape typical of many engineering structures. The full-field measured data are highly redundant, but the application of image processing using functional transformation enables the extraction of a small number of shape features without any significant loss of information from the raw DIC data.[5]

B. Ultrasonic Method:

The ultrasonic torsion converter transforms the sinusoidal power signal into mechanical twist oscillations and injects torsion waves into one end of the load train. Such converters are commercially available and consist of ferroelectric ceramic layers in the centre and solid aluminium alloy cylinders at both ends. The ferroelectric ceramic layers generate shear oscillations of sufficient magnitude, if the stimulation frequency is equal to the resonance frequency of the converter, i.e. if half wavelength of the generated torsion waves coincides with the length of the converter. All components of the load train must be designed appropriately to allow the formation of a standing wave at the resonance frequency of the ultrasonic torsion converter, which is 20 kHz in the present case. The design of the ultrasonic torsion load train is based on principles described by Mori and Uno and the actual realization using titanium alloy Ti6Al4V to manufacture the components.[5]

C. Interferometer Method:

Digital speckle pattern interferometer (DSPI) technique is a full field, non-contact, non-evasive and almost real time method to measure the vibrations of structures subjected to various kinds of loading. DSPI is faster in operation and less sensitive to environmental perturbations than holography. In DSPI, the speckle pattern is formed by illuminating the surface of the object by laser light. The object wave is imaged on the photosensitive part of the CCD camera where it is allowed to interfere with an in-line reference beam. The interferograms of two different states of the object are grabbed and subtracted. The speckle correlation fringes are thus displayed on computer monitor using digital techniques.[5]

D. Accelerometer with FFT:

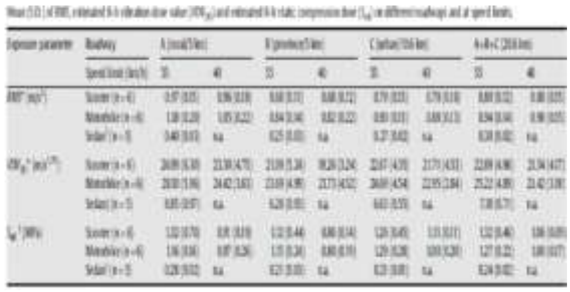
The purpose of this system is: 1. To gather real-time field vibration data for the future use in the seat suspension system simulation research. 2. To have the means to analyse the seating dynamics concurrently in three mutually perpendicular axes. In this way, the various interactions could be analysed in each vehicle. The research effort could then focus on the vibration mitigation in the axis of the highest influence (acceleration value).[5]

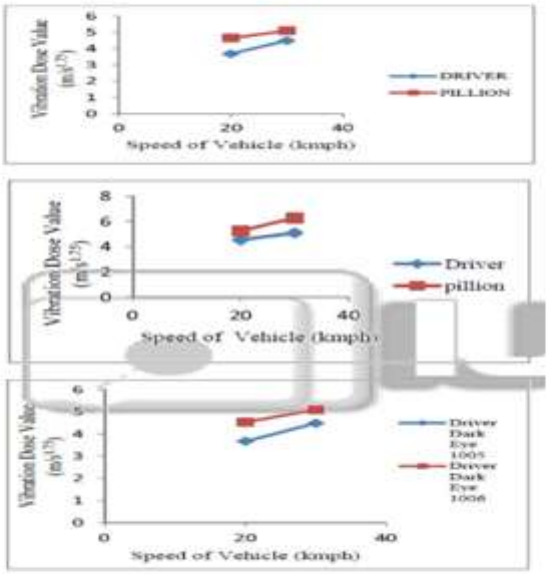
V. Study Of Vibration Exposure Of The Motorcyclriders

ISO 2631-1, or had Sed (mean 1.17 MPa) exceeding the value associated with a high probability of adverse health effects (0.8 MPa) recommended by ISO 2631-5. Over 50% of the motorcycle riders reached these boundary values for VDV and Se in less than 2 h. This study found that RMS produced much lower results for WBV exposure in motorcycle riding than VDV and Se. This observation indicates that a motorcycle rider encounters many shocks.Vibration peak distributions encountered by motorcycle riders result from a combination of riding speeds and road profiles.

VI. Result Of Whole Body Vibration Exposure Of Thetwo Wheeler Rider And Different Speed Breaker Type

Vikas Kumar, et al determined the Results of whole body vibration exposure of the two wheeler rider and different speed breaker type fig: 2 shows that, for driver and pillion,the VDV value at speeds 20 kmph and 30 kmph are 3.7 $ms^{-1.75}$, 4.4 $ms^{-1.75}$ and 4.6 $ms^{-1.75}$, 5 $ms^{-1.75}$ respectively for the speed breaker DARK EYE DA 1005(). shows thatfor driver and pillion, the VDV value at speeds 20 kmph and 30 kmph are 4.5 $ms^{-1.75}$, 5 $ms^{-1.75}$ and 5.2 $ms^{-1.75}$, 6.2 $ms^{-1.75}$respectively for the speed breaker of DARK EYE DA 1006 VDV value for the driver has been found to be less compared to the pillion for both the speed breakers i.e. driver is exposed to less vibration severity as compared to the pillion on the same vehicle. shows that VDV values for driver at 20 kmph 30 kmph for speed breakerDARK EYE DA 1005 and DARK EYE DA 1006 are 3.7$ms^{-1.75}$, 4.5$ms^{-1.75}$ and 4.4 $ms^{-1.75}$ and 5$ms^{-1.75}$ respectively. It isrecommended that the speed breaker DARK EYE DA 1005 be used instead of DARK EYE DA 1006 to keep the VDV within the acceptable limit and preventing adverse health effects. [6].





VII. CONCLUSION

The crest factor (CF) is a dimensionless quantity defined as the ratio of the peak acceleration to the r.m.s acceleration. If any signals contained a single instantaneous shock, then the CF would increase, but the r.m.s. might not be substantially affected. The Value of CF indicates whether r.m.s. or Vibration dose value (VDV) is appropriate for the assessment of whole body vibration. The CF threshold is not universally agreed upon, BS 6841 (1987) and ISO-2631 standards define a CF value of 6 and 9 to designate when r.m.s. method become inferior to VDV method. the RMS does not properly address transient shocks, and that the Sed (Static compression dose) value is more rigorous than RMS when evaluating health effects. The nature of vibration that is present in a vehicle depends upon the dynamic characteristics of the automobile and road surface characters. Its effect on the human body depends mainly on the frequency, magnitude, direction, area of contact and duration of exposure.If possible it is necessary also to avoid vibrational frequency below 90 hz.

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