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ANALYSIS OF SEAT TO HEAD TRANSMISSIBILITY OF VIBRATIONS FOR A TRACTOR DRIVER, ON AN UNEVEN LAND, BASED ON BIOMETRICS ACQUISITION SYSTEM

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Abstract: The article aims to present the measurements of whole-body vibrations (WBV) and the calculation of seat-to-head transmissibility (STHT) for an agricultural tractor driver. Measurements were taken on a diesel tractor model TD80D and an electric tractor model TE-0. The measurements were performed under real operating conditions on a rough road at a speed of 5 km/h. Vibration levels were measured using five tri-axial accelerometers from Biometrics Ltd and NexGen Ergonomics. Data were collected simultaneously in real-time from all sensors using three Data Log units from the Biometrics Ltd data acquisition and processing system. The results obtained using Vats software after the comparative analysis are in accordance with the standard that describes the evaluation of human exposure to whole-body vibrations, ISO 2631-1, in the frequency range of 0-80 Hz.
Key words: *Whole Body Vibrations, accelerometers, Biometrics, Vats, seat to head transmissibility, isolation efficiency, electric tractor, diesel tractor.*

1. INTRODUCTION

Contingent upon the classification of the heavy vehicle, whether it is a diesel agricultural tractor or an electric one, operators may be subjected to significant levels of low-frequency vibrations, predominantly arising from the vehicle itself and its interaction with the underlying terrain, leading to the appearance of driver discomfort [1]. Therefore, these risks are defined as whole-body vibrations (WBV) [2-4]. Specialized literature highlights effects such as fatigue, muscle and joint pains, and, sometimes, circulatory and digestive disorders [5-10]. Prolonged exposure to low-frequency vibrations is associated with adverse effects, including lower back pain [11-13].

The interaction between the tractor and the terrain, along with factors such as the tractor's flooring, seat type, seat backrest inclination angle, steering wheel, and engine type, constitute the primary contact points through which vibrations are transmitted to the operator’s body [14-16]. The critical resonance frequency of the human body falls within the range of 4-8 Hz, while agricultural tractor operators are subjected to vibrations in the 1-10 Hz frequency range, encompassing the body’s natural resonance frequency [17]. Numerous studies in the specialized literature describe the optimal compromise between the effective acceleration transmitted to the human body and the relative displacement of the suspension system, employing the weighted summation method. Dynamic characteristics of the tractor type and suspension type, as well as anthropometric characteristics of the human driver, are used in the analysis and evaluation of the transmissibility from seat to head of the vibrations and their isolation [18-23].

Tractor vibrations are simultaneously collected following the length of the three translational axes: longitudinal (X), lateral (Y), and vertical (Z), as shown in Figure 1, in which (S) represents the contact interface between the seat and the buttocks where an accelerometer sensor is mounted, and (F) is the mounting position of the accelerometer sensor on the tractor floor.

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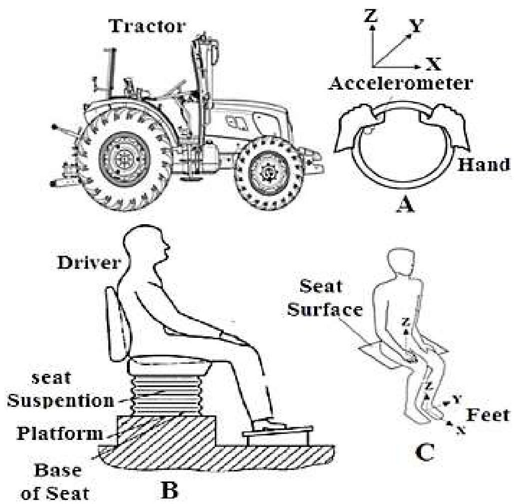


Figure 1. A- The placement of the accelerometer on the steering wheel. B - The position of the tractor driver, the operator's seat suspension, and the platform. C-The position of the accelerometer on the seat surface and on the tractor's platform across the three axes: longitudinal X, lateral Y, and vertical Z. [24]

2. EXPERIMENTAL PROTOCOL

For this study, two types of tractors were used: a DT model New Holland TD80D [25] and a prototype ET TE-0 [26]. The assessments were performed within real road state, where the terrain profile bumps had a depth of 5 cm, and the soil moisture of the bumpy terrain was 9.3%, at the National Institute for Research and Development in Machines and Installations for Agriculture and Food Industry – INMA Bucharest. From the operator sample, a male subject aged 27 years, having a height of 180 cm and a body weight of 80 kg, who held a driving license, was selected. He participated voluntarily during the evaluation tests, following the completion of a consent agreement.

Both types of tractors that were driven on bumpy (uneven) terrain are shown in Figure 2, while the vehicle specifications are presented in Tables 1 and 2.

The experimental assessments of the effects of vibrations on the human body seated in the driver's position were duly approved by the Ethics Committee of the University of Craiova.

(Diesel Tractor - DT) (Electric Tractor - ET)

Figure 2. Presentation of tractor models

Table 1.

Technical details of DT

Model	**TD80D**
Distributor	New Holland
Motor Power	73 HP / 53.7 [kW]
Wheelbase	2310 [mm]
Height	2560 [mm]

Table 2.

Technical details of ET

Model	**Electric tractor TE-0**
Distributor	INMA
Motor Power	39.2 HP / 28.8 [kW]
Wheelbase	2060 [mm]
Height	2325 [mm]

2.1 The equipment for data acquisition

The data acquisition apparatus utilized was the Vibration Analysis Toolkit (VATS), manufactured by NexGen Ergonomics [27], which operates within the Biometrics LTD data acquisition system [28], commonly used software in scientific research on human biomechanical evaluations, medical robotics or rehabilitation [29-36]. For this study, 3 data acquisition units, MWX8 Data LOG device (shown in Figure 3) from Biometrics Ltd system, were used to collect data from accelerometers on X, Y, Z axis simultaneously, conducted in real-time to a PC through Bluetooth®, guaranteeing accurate real-time data recording, transfer, and visualization.

Five three-axial accelerometers S2A-16G-MF, shown in Figure 4, were used, mounted on the two types of tractors, shown in Figures 5-8. The S2A-16G-MF accelerometer is a precision accelerometer with 3 axes of 16G with offset and sensitivity, signal dampers, and adjustable filters for each channel.

Figure 3. The equipment MWX8 Data LOG

Figure 4. The Data LOG MWX8 equipment

Figure 5. Mounting accelerometers on the seat and seat back

Figure 6. TD80D DT

Figure 7. Accelerometers on the driver's seat and cap

Figure 8. TE-0 ET

An accelerometer sensor was mounted on a rubber pad on the seat of both tractors; the second one was mounted on the backrest of the seat, centered on the position along the seatback's central line, which was in the main body support area. A sensor was installed on the tractor cabin floor, adjacent to the driver's supporting leg, to facilitate the acquirer of all signals produced by the vibrations occurring during the tests, including the tractor's own vibrations during operation. Another sensor was mounted on the steering wheel at the midpoint of the grip area, and a sensor was mounted at head level of the driver on the occipital ridge, attached with the help of a cap to keep the accelerometer support band in place.

3. MEASUREMENTS WITH VATS

The VATS software is created in accordance with ISO 2631-1 standard, which characterizes the evaluation of human exposure to WBV [37]. The accelerations were subject to frequency-weighted utilizing the vertical (W_k) and horizontal (W_d) weighting curves, acquiring the acceleration measurements a_{wx}, a_{wy}, and a_{wz} in accordance with ISO 2631-1.

The root mean square acceleration, $a_{w\,\text{r.m.s}}$, is calculated as follows [37]:

$$a_{w\,\text{r.m.s}} = \left[\frac{1}{T}\int_0^T a_w^2(t)dt\right]^{1/2} \quad (1)$$

Where: $a_w^2\,(t)$ frequency - weighted acceleration at time t,
T is the measurement time.

The overall magnitude of the oscillating motion is determined by [12]:

$$a_{W_v} = \sqrt{k_x\, a_{W_x}^2 + k_y\, a_{W_y}^2 + k_z\, a_{W_z}^2} \quad (2)$$

In which, k_x, k_y, and k_z are scaling factors for the measurement axes X, Y, and Z.

Each series of experimental trials was conducted in a predefined sequence; the data collection process consisted of three trials per experiment each within a 180-second interval, allowing both tractors to reach the target speed (5 km/h).

4. VATS Time/Frequency Graphs

Case I. DT model TD80D, uneven terrain, speed 5 km/h

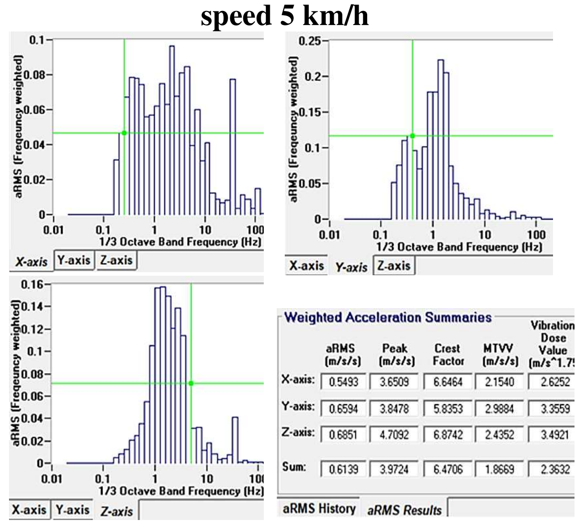
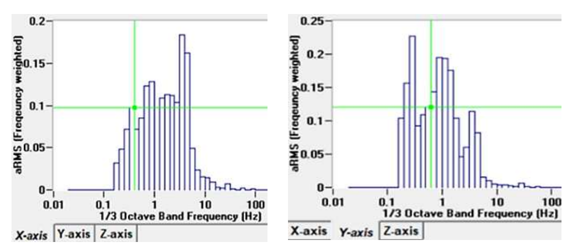


Figure 9. aRMS variation on time along the three axes, during collecting data on the flooring of the tractor, at the seat's base level.



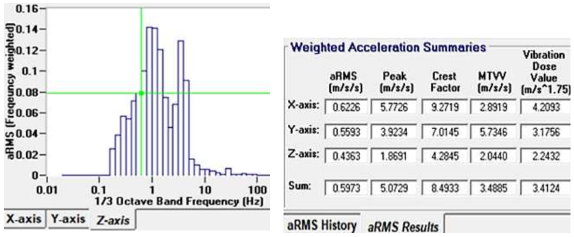


Figure 10. aRMS variation on time during collecting data on the seat cushion and seat back.

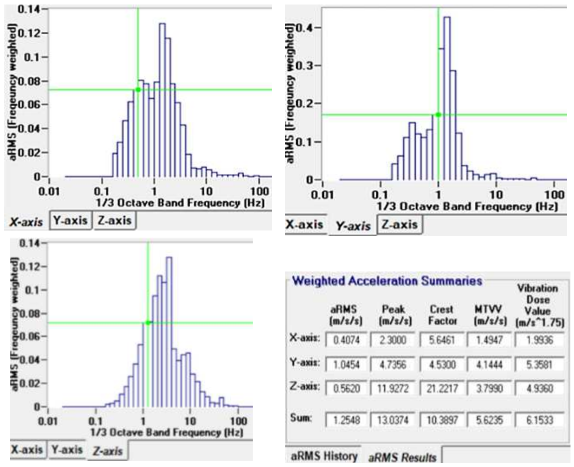


Figure 11. aRMS variation on time during collecting data at the operator's head.

Case II. Electric tractor TE-0 on uneven terrain at 5 km/h.

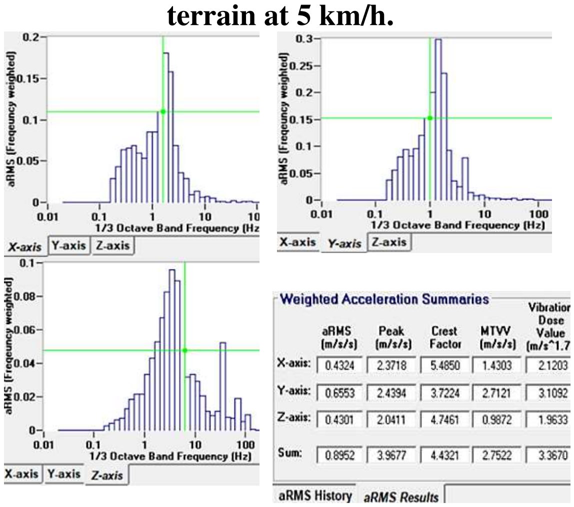
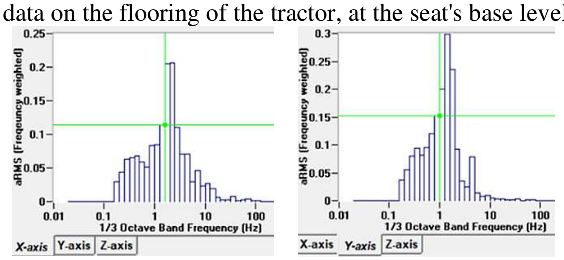


Figure 12. aRMS variation on time during collecting data on the flooring of the tractor, at the seat's base level.



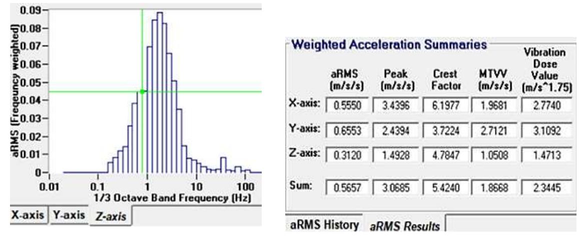


Figure 13. aRMS variation on time during collecting data on the seat cushion and seat back.

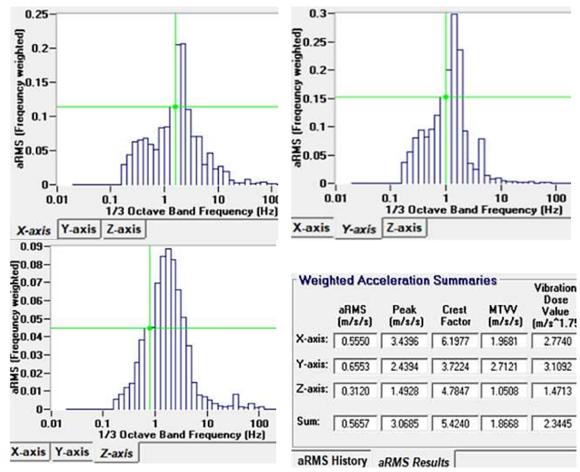


Figure 14. aRMS variation on time during collecting data at the operator's head.

4.1 Transmissibility

For this study, the data from the uneven terrain type at a velocity of 5 km/h, axis Z for both the DT and the ET were processed. FFT (Fast Fourier Transform) is utilized to transform the signals from the time domain X(n) to the frequency domain X(f), as described by the following mathematical relation [38]:

$$X(f) = 1/N \sum_{n=0}^{N-1} \mathrm{x}[\mathrm{n}]\, e^{-i2\pi\frac{f}{N}} \ , \qquad (3)$$

In which: f = 0, 1, 2 … N-1

It is described by the memory length N (=1, 2, 3...) and represents a discrete-time signal x[n] as a vector with N complex elements, where f signifies the discrete frequency.

The resulting data in the frequency domain are used in Microsoft Excel for calculating transmissibility (T).

$$\mathrm{T} = \left| \frac{\mathrm{A0}}{\mathrm{Ai}} \right| = \sqrt{\frac{1+(2\varepsilon\frac{fd}{fn})^2}{\left[1-\left(\frac{fd}{fn}\right)^2\right]^2 + [2\varepsilon\frac{fd}{fn}]^2}} \qquad (4)$$

Where: A_0 – Magnitude of the vibrational response; A_i – Magnitude of the vibrational input; ε – Damping factor; f_d = Excitation frequency; f_n = Resonant frequency. For the calculation of transmissibility, the acceleration levels A_0 and A_i are taken at the same frequency fn. [Hz] [39].

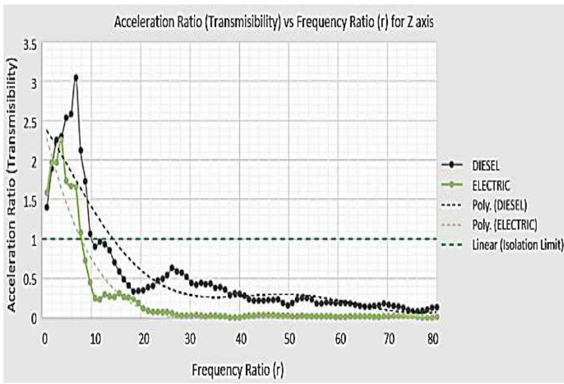


Figure 15. Transmissibility on the Z-axis, uneven terrain, speed of 5 km/h	
The polynomial equation for the DT	The polynomial equation for the ET
$y = -2E\text{-}10x^6 + 6E\text{-}08x^5 - 6E\text{-}06x^4 + 0.0003x^3 - 0.0037x^2 - 0.0915x + 2.4666$, (5)	$y = 2E\text{-}11x^6 - 1E\text{-}08x^5 + 2E\text{-}06x^4 - 0.0002x^3 + 0.0107x^2 - 0.2662x + 2.53$, (6)
$R^2 = 0.8418$	$R^2 = 0.9161$

The curve fitting function is applied to all resulting values (T), and a sixth-degree polynomial curve is chosen to ensure that the coefficient of determination R^2 closely approaches 1.

The graph illustrates the polynomial representing the transmissibility for the ET (green) and the DT (black). The level at which vibrations are effectively isolated and no longer transmitted from the flooring of the tractor to the driver's head is indicated by the dashed green horizontal line, referred to as the transmission unit line.

Figure 16 displays the graph of the average isolation efficiency [dB] for the vertical measurement axis Z, comparing the DT model 80D and the ET model TE-0 on uneven terrain at a driving speed of 5 km/h.

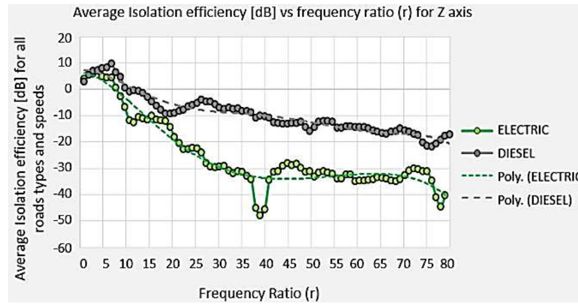


Figure 16. The average isolation efficiency [dB] based on uneven terrain and a speed of 5 km/h.

Figure 17 presents a comparative graph demonstrating the average vibration isolation efficiency of diesel and electric tractors on irregular terrain at a specified speed of 5 km/h.

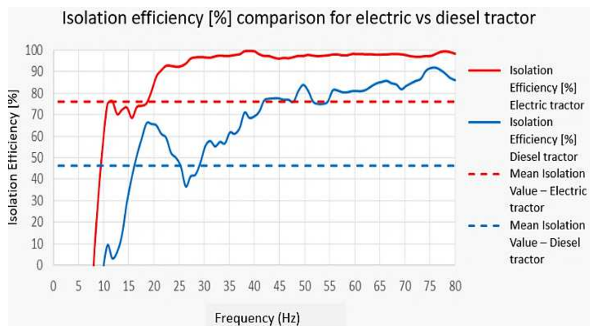


Figure 17. The average isolation efficiency [%] relative to uneven terrain and speed (5 km/h)

The obtained values suggest that the ET achieved a significantly higher average isolation efficiency of 76.10% compared to the DT, which was 46.21%.

5. DISCUSSIONS

For the DT, the average RMS vibration level on the Z-axis reached 0.6851 m/s² at the tractor floor level, 0.4363 m/s² at the seat and seat back level, and 0.5620 m/s² at the height of the operator's head. For the ET, the average RMS vibration level on the Z-axis reached 0.4301 m/s² at the tractor floor level, 0.3120 m/s² at the seat and seat back level, and 0.2381 m/s² at the operator's head level.

The human body's capability to transfer vibrations is determined by its ability to convey biodynamic responses, particularly in areas where vibrations enter the body (such as the tractor seat) and where vibrations are measured at the body level (the driver's head). The transmissibility values obtained in this study for the two types of tractors, are validated by the range of similar values obtained in studies from the specialized literature in the reference articles [39-42].

6. CONCLUSION

Following the comparative analysis of the whole-body vibration transmissibility and efficiency from the seat to the head for a diesel and electric tractors driver on a rough road, we can conclude that the transmissibility for the DT had a value of 3.04 at a frequency of 6.8 Hz, assessed in relation to the ET, which had a transmissibility value of 2.25 at a frequency of 3.9 Hz. The DT had a vibration isolation frequency at 9.8 Hz compared to the electric one at 7.9 Hz (Figure 16). The average efficiency of vibration isolation in the 0-80 Hz interval for the electric tractor is -25 [dB] or 76.1 [%], compared to the DT, which achieved an average efficiency of vibration isolation of -9.3 [dB] or 46.26 [%]. This significantly superior comparative difference of the electric tractor signifies a greater and more efficient vibration isolation, representing an effective ergonomic condition for encouraging the use of electric tractors, considering the improved comfort and health condition of the driver (Figure 17).

For a heavy tractor vehicle driver, the main characteristics of the human body's reaction to vibrations relies on several elements, which vary depending on the situation, such as the level of excitement, body posture while driving, as well as muscle tone or concentration state. According to ISO 2631-1 regarding symptoms experienced by the human body with WBV, the difference from 3.9 Hz, which is the isolation zone of the electric tractor, to 7.9 Hz, which is the isolation frequency of the DT, may induce certain effects on the driver, such as moderate feelings of discomfort and abdominal pains.

From the presented graphs regarding the isolation efficiency of vibration levels for the two types of tractors, electric and diesel, it can be observed that for the electric tractor, the isolation efficiency exceeds the threshold of 75%, which means very good efficiency due to the functional and performance parameters of the tractor during experimental tests, significantly reducing the levels of vibration emission propagated throughout the body.

7. REFERENCES

1. Mandapuram, S., Rakheja, S., et. al. *Energy absorption of seated body exposed to single and three-axis whole body vib.,* J. Low. Freq. Noise Vib. A. Control, 34, pp. 21–38, 2015.
2. Singh, A., et. al. *Evaluation and analysis of whole-body vib. exposure during soil tillage operation*, Safety, 7, pp. 61-71, 2021.
3. Singh, A., et. al. *Evaluation and analysis of occupational ride comfort in rotary soil tillage operation*, Measurement 13, pp. 19–27, 2019.
4. Scarlett, A.J., Price, J.S., et. al. *Whole-body vibration: evaluation of emission and exposure levels arising from agricultural tractors*, J. Terramech., 44, pp. 65–73, 2007.
5. Meng, X., Tao, X., et. al. *Effects of Sinusoidal Whole Body Vibration Frequency on Drivers' Muscle Responses*, SAE World Congress & Exhibition, 1, pp. 1396, 2015.
6. Kia, K., Harold, T.B., et. al. *Evaluation of vertical and multi-axial suspension seats for reducing vertical-dominant and multi-axial whole-body vibration and associated neck and low back joint torque and muscle activity*, Ergonomics, 65, pp. 2002-2018, 2022.
7. Kia, K., et al. *Evaluation of Multi-axial Active Suspension to Reduce Whole Body Vib. Exposures and Associated Biomecha-nical Loading in Mining Heavy Equipment Operators*, HFES, 63, pp. 352-368, 2019.
8. Mohammed, H.U., Bhuiyan, M., et. al. *Effects of whole-body vibration on driver drowsiness: A review*, Journal of Safety Research, 81, pp. 175-189, 2022.
9. Bovenzi, M., Hulshof, C.T.J., *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, pp. 595-611, 1998.
10. Griffin, M.J., *Predicting the hazards of whole-body vibration considerations of a standard*, Industrial H, 36, pp. 83-91, 1998.

11. Johnson, D.A., Nève, M., *Analysis of possible lower lumbar strains caused by the structural properties of automobile seats: a review of some recent technical literature*, Journal of Manipulative and Physiological Therapeutics, 24, pp. 582-588, 2001.
12. Singh, A., Siby, S., et. al. *Whole-body vibration: Characterization of seat-to-head transmissibility for agricultural tractor drivers during loader operation*, Smart Agricultural Technology 4, 100164, 2023.
13. Park, D.J., Choi, M.G., et. al. *Attention decrease of drivers exposed to vibrations from military vehicules, when driving in terrain cond.*, Int. J. Ind. Ergon. 72, pp. 363–371, 2019.
14. Oncescu, T.A.,et al., *Evaluation of whole-body vibration and comfort state of tractor driver for different types of terrain and speeds*, Acta Technica Napocensis-series: Applied Maths, Mech. and Eng., 64(1), pp. 153-160, 2021.
15. Oncescu, T.A. et. al. *Influence of the road type on the whole-body vibrations transmitted to the driver of an electric tractor*, Acta Technica Napocensis: Applied Mathematics, Mech. Eng., 65(2s),pp.387-392, 2022
16. Village, J., Trask, C., et. al. *Assessing whole body vibration exposure for use in epidemiological studies of back injuries: measurements, observations and self-reports*, Ergonomics 55, pp. 415–424, 2012.
17. Griffin, M.J., *Discomfort from feeling vehicle vibration*, Veh. Syst. Dyn. 45 pp. 679–698, 2007.
18. Maciejewski, I., Meyer, L., et. al. *Modelling and multi-criteria optimisation of passive seat suspension vibro-isolating properties*, J. S.Vib., 324, pp. 520–538, 2009.
19. Segla, S., Trisovic, N., *Modeling and optimization of passive seat suspension*, Am J. Mech. Eng., 1, pp. 407–411, 2013.
20. Maciejewski, I., Kiczkowiak, T., et. al. *Application of the Pareto-optimal approach for selecting dynamic characteristics of seat suspension systems*, Veh. Syst. Dyn., 49, pp. 1929–1950, 2011.
21. Stein, G.J., Zahoransky, R., et. al. *Modelling and simulation of a fore-and-aft driver's seat suspension system road excita-tion*, Int. J.Ind. Ergon, 38, pp. 396–409, 2008.
22. Bluthner, R., Hinz, H., et. al. *On the significance of body mass and vibration magnitude for acceleration transmission of vibration through seats with horizontal suspensions*, J. Sound Vib., 298, pp. 627–637, 2006.
23. Fleury, G., and Mistrot, P., *Numerical assessment of fore-and-aft suspension performance to reduce whole-body vibration of wheel loader drivers*, J. Sound Vib., 298, pp. 672–687, 2006.
24. Ahmed, A.A.H., *Measuring vib. at tractor platform, steering wheel and seat effective amplitude transmissibility factor during operation tillage*, The Iraqi Journal of Agricultural Sci., 47(1), pp. 365-378, 2016.
25. New Holland TD80D tractor information, https://www.tractordata.com.
26. https://inma.ro/wp-content/uploads/2020/12/pagina-web_final_contract-1PS.pdf
27. Vibration Analysis Toolset (VATS), www.nexgenergo.com/ergonomics/vats.html
28. DataLOG (MWX8), Analysis Software for DataLOG, http://www.biometricsltd.com.
29. Tarnita, D., Geonea, I., et. al. *Numerical Simulations and Experimental Human Gait Analysis Using Wearable Sensors, New Trends in Medical and Service Robots 48*, Springer, pp. 289-304, 2018.
30. Tarnita, D., et al. *Experimental characterization of human walking Applied to Humanoid Dynamics*, Advances in Robot Design and Intelligent Control, RAAD16, Springer, 540, pp. 293-301, 2017.
31. Geonea, I.D., et. al. *Dynamic analysis of a spherical parallel robot used for Rehabilitation*, Applied Sciences, 11, pp. 11849, 2021.
32. Tarnita, D., et al., *Applications of Nonlinear Dynamics to Human movement on Plane & Inclined Treadmill*, New Trends in Medical& Service Robots, Springer, 39, pp.59-73, 2016.
33. Berceanu, C., et al., *About an experimental approach used to determine the kinematics of the human*, Journal of the Solid State Phenomena, Robotics and Automation Systems, 166-167, pp. 45-50, 2010.

34.Tarnita, D., Tarnita, D.N., Bizdoaca, N., Popa, D., *Contributions on the dynamic simulation of the virtual model of the human joint,* Materialwissenschaft und Werksto fftechnik, Materials Science and Engineering Technology, 40(1-2), pp. 73-81, 2009.

35. Tarnita, D., Catana, M. and Tarnita, D.N., *Experimental measurement of flexion-extension movement in normal human knee. Rom J Morphol Embryol*, *54*(2), pp.309-313, 2013

36. Pisla, D.; Nadas, I.; Tucan, P.; et al., *Development of a Control System and Functional Validation of a Parallel Robot for Lower Limb Rehabilitation*. Actuators, 10, 277, 2021.

37.International Organization for Standardization, 1997. International Standard 2631-1:1997 Mechanical Vibration and Shock-evaluation of Human Exposure to Whole-Body Vib. Part 1.

38. Zeinab, K., Hojjat, A., et. al. *Whole Body Vibration Analysis of Tractor Operators Using Power Spectral Density*, J. of Mech. Eng. and Technology, 1(1), pp. 6-12, 2013.

39. Roger Corporation, *Vibration Isolation and Damping, the Basics*, http://www.vibrationdata .com/tutorials2/VibrationIsolation Basics.pdf.

40. Ivo, J., et. al. *An overview of strategies to reduce whole-body vibration. exposure on drivers*, *A systematic review*, International J. of I. E., 37, pp.245–256, 2007.

41. Aisyah, A.S., et. al. *Mathematical Model of Suspension Seat-Person Exposed to Vertical Vibration for Off-Road Vehicles*, Intern Journal of Automotive and Mechanical Engineering, 16(2), pp. 6773-6782, 2019.

42. DeShaw, J., et al., *Effective seat-to-head transmissibility under combined-axis vibration and multiple postures*, Int. J. Vehicle Performance, 1, No.3/4, pp. 235-253, 2014.

Analiza transmisibilității vibrațiilor de la scaun la cap pentru un șofer de tractor, pe un teren denivelat bazata pe sistemul de achiziții de date BIOMETRICS

Rezumat: Articolul vizează prezentarea măsurătorilor vibrațiilor întregului corp (WBV) și calcularea transmisibilității de la scaun la cap (STHT) pentru un conducător auto de tractoare agricole, măsurători făcute pe un tractor diesel model TD80D și un tractor electric model TE-0. Măsurătorile au fost efectuate în condiții reale de funcționare a tractoarelor, pe un drum denivelat cu viteza de 5 km/h. Nivelurile de vibrații au fost măsurate cu ajutorul a 5 accelerometre triaxiale din gama Biometrics Ltd și NexGen Ergonomics, Datele au fost colectate simultan în timp real de la toți senzorii cu ajutorul a 3 unități Data Log a sistemului de achiziții și prelucrări de date Biometrics Ltd. Rezultatele obținute cu ajutorul softului Vats în urma analizei comparative sunt în conformitate cu standardul care descrie evaluarea expunerii umane la vibrațiile întregului corp ISO 2631-1, în intervalul de frecvență 0-80 Hz.

Cuvinte cheie: *Vibrații pentru întregul corp, accelerometre, biometrie, cuve, transmisibilitate scaun la cap, eficiență de izolare, tractor electric, tractor diesel*

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