# 560. Research of influence of mechanical vibrations on humans

**V. Fliegel[1], R. Martonka[2], J. Petřík[3],**
Technical university of Liberec, Liberec, Czech Republic
**E-mail:** [1] *vitezslav.fliegel@tul.cz*; [2] *rudolf.martonka@tul.cz*; [3] *jan.petrik@tulcz*

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**Abstract.** Car seat producers and research laboratories are focused on the influence of mechanical vibrations on humans. It stands to reason that value of transmissibility of mechanical vibrations onto human body depends on quality of vibro-isolation properties of car seat. Negative effects of mechanical vibrations to a person may be characterized by means of events and parameters, changes in health state, rising temperature and blood pressure, accelerated breath, short-time and long-time tediousness, etc. Mechanical vibrations evoke mechanical oscillations of human body in relation to its intensity. Determination of absorbed–dissipated energy in human body is the object of research and summary of this article.

**Keywords:** Dissipated energy, shaking, mechanical vibrations, tiredness

## Introduction

The evaluation of mechanical vibration effect employs acceleration measurements to obtain transmissibility behavior in different layers, e.g. excitation or contact layer. It is insufficient for determination of mechanical vibration and tiredness of the human. It is necessary to use energy evaluation and dissipation balance to describe correlation between tiredness and mechanical vibration effect.

## Theory

It is possible to characterize intensity of mechanical vibrations by using mechanical energy. It is important to divide energy into positive and negative half-wave. Total energy $E_i$, goes over measured layer i, is defined as a sum of positive half-wave energy $E(+)_i$ and negative half-wave energy $E(-)_i$. Positive half-wave energy $E(+)_i$ is defined as integral of positive half-wave power $P(+)_i$ and negative half-wave energy $E(-)_i$ is defined as integral of negative half-wave power $P(-)_i$ .

$$E_i = E(+)_i + \left|E(-)\right|_i \tag{1}$$

$$Ed_i = E(+)_i - \left|E(-)\right|_i \tag{2}$$

$$E(+)_i = \int P(+)_i \, dt \tag{3}$$

$$E(-)_i = \int P(-)_i \, dt \tag{4}$$

Power is defined as simple product of force and velocity in measured layer. Power is possible to divide into positive and negative half-wave. If the direction of contact layer power vector and velocity vector is the same, it is the positive half-wave. If the direction is opposite, it is the negative half-wave.

$$P(+)_i = F_i(-) \cdot v_i(-) \tag{5}$$

$$P(-)_i = F(-)_i \cdot v_i(+) \tag{6}$$

## Mathematical experiment

Mathematical experiment (model) is based on theory above and is composed of two components. Each of them consists of rigid mass, suspension component and damping component. Separate component (mass + suspension + damper) represents physical and vibro-isolation behavior of material between separate layers.

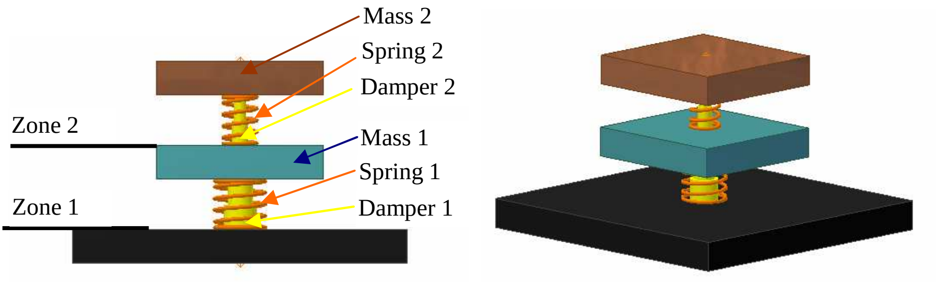


**Fig. 1.** Mathematical model with 2 zones and 2 components

The following figures demonstrate time characteristics of force (fig. 2), velocity (fig. 3) and power (fig. 4) on measuring zone 1.

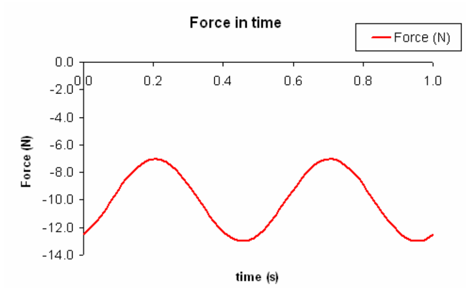


**Fig. 2.** Force in time

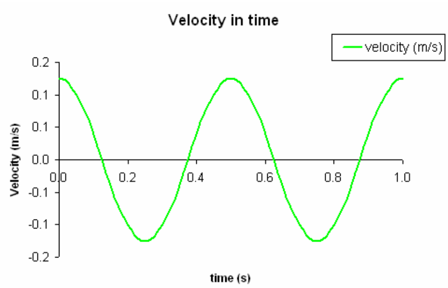


**Fig. 3.** Velocity in time

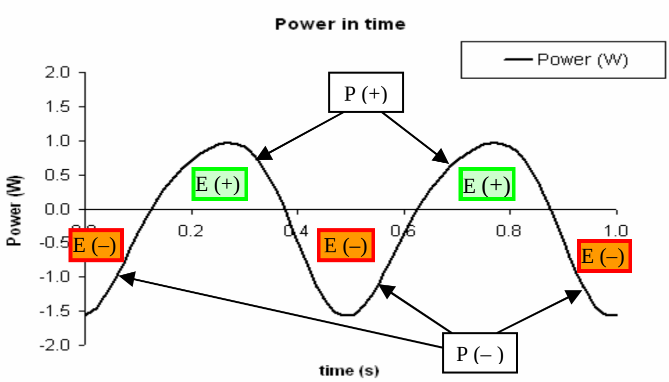


**Fig. 4.** Power in time

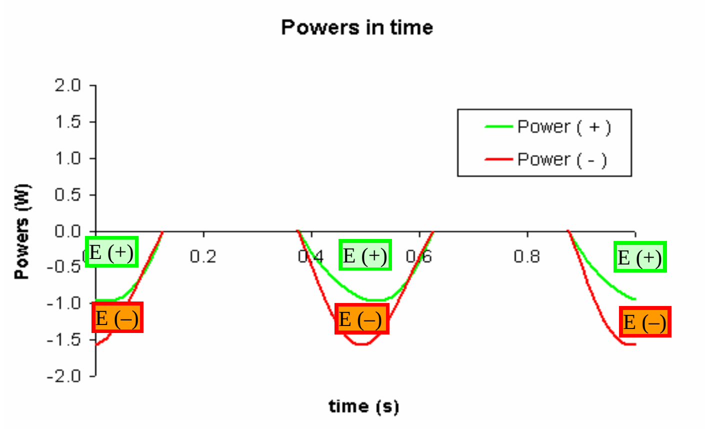


**Fig. 5.** Comparison half wave of powers (energy)

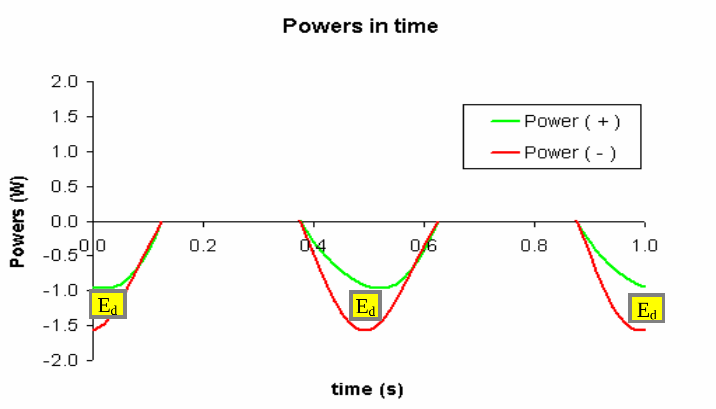


**Fig. 6.** Comparison half wave of powers – dissipated energy

These equations and time responses may be defined for every measured layer. It is possible to compare damping behavior of the comfort layer of the seat and human by using dissipation energy.

$$Ed_{12} = Ed_1 - Ed_2$$
$$Ed_{23} = Ed_2 - Ed_3$$
$$\ldots$$
$$\ldots$$
$$Ed_{ij} = Ed_i - Ed_j$$

## Upcoming experiment

We are able to characterize influence of mechanical vibratiosn on human by applying mechanical energy. It is possible to use force sensors in separate layers (e.g. GTM 2.5kN) (fig.7.) or pressure distribution sensor (e.g. XSensor) (fig.8.). There are no sensors for direct measurement of velocity. Acceleration or displacement sensors are always used and it is necessary to integrate or derivate signal in order to determine velocity. HBM acceleration sensors are used in our case (fig. 9.).

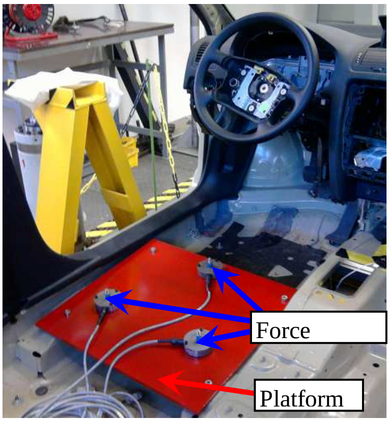


**Fig. 7.** Load cells (GTM)

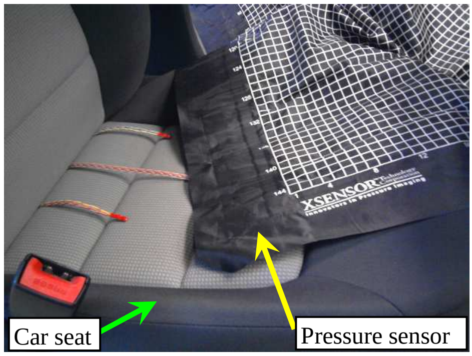


**Fig. 8.** Pressure sensor (XSensor)

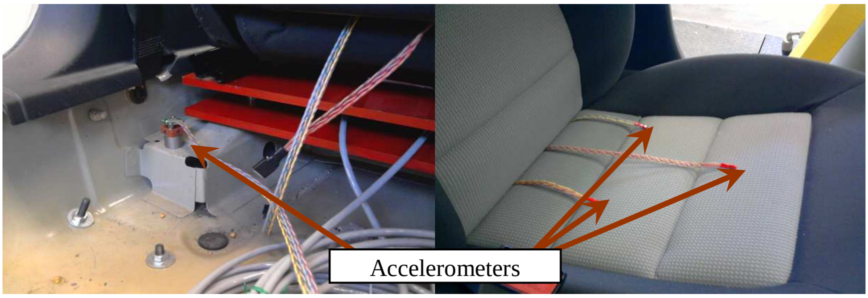


**Fig. 9.** Accelerometers

Testing persons and testing signals according to TAS TUL methodology will be chosen after calibration of all sensors. Developed results will correspond to theory above; i.e. for every person dissipation energy will be different.

## Conclusions

Theory indicates that dissipation energy for different materials is not the same. We hope that real experiments will reveal that dissipation energy for different person will be diverse. It will be in direct correlation with their short time tiredness. If the dissipation energy increases, tiredness of a person will increase as well. We need to reduce the level of dissipation energy. It is possible to optimize structure of the seat and comfort layer material.

## References

**[1]** ISO 2631 standard.
**[2]** **Demic M., Lukic J., Milic Z.** Some aspects of the investigation of random vibration influence on ride comfort, "Journal of Sound and Vibration", 2002.
**[3]** **Rakheja S., Stiharu I.** Seated occupant apparent mass characteristics under automotive postures and vertical vibration, "Journal of Sound and Vibration", 2002.
**[4]** Catalog GTM force sensors.