

19. Conclusions

This book provides a discussion on vibration problems in means of transport. The issues addressed in the book include the identification of vibration sources and analysis of propagation and structure of vibrations affecting men in means of transport basing on the example of automotive vehicles. The author proposes specific methods dedicated for following characteristics identification: vibration structure in the function of time, frequency and time-frequency distributions vibration structure of wave propagation in three orthogonal axes as well as vibration distribution in a vehicle structure.

A majority of studies pertaining to vibrations in automotive vehicles focuses on vehicles in motion, subject to numerous dynamic impacts. The vibration waves being generated propagate into the vehicle structure and, via the body and equipment components, they are transferred to traffic participants. The book presents the experimental research analysis of natural vibrations of vehicle structures from the perspective of the most vital element in terms of the human exposure to vibration – the floor panel. The analysis of the results obtained and described in Chapter 5 enabled identification of characteristics of the vehicle floor panel vibrations.

The Chapters 6 to 10 present studies of the impact exerted by the technical condition of suspension components and the chosen operating parameters of a vehicle on the propagation of vibrations generated by a road wheel vertical motion to the vehicle. The purpose of those studies was to identify factors affecting the propagation of vibrations caused by the dynamic impact of road irregularities on wheels of a moving vehicle. Exposure to vibration in means of transport depends on many factors. For the perception properties as type of vibration the value, dynamics and exposure time of chosen frequency components of the vibration can be considered. The possibilities of simultaneous observation of signal in time and frequency domains distribution are reached by the time-frequency representation (TFR) of the signal. The Chapter 8 addresses analysis results of one of the TFR techniques application for the structure of vibration identification. The possibilities of characteristics components of vibration structure and sensitivity identification on the changes in mechanical system parameters were investigated on the research results concerning influence of technical condition of suspension and operating parameters of the vehicle.

The Chapters 9 and 10 describe proposition of function represents structure of vibration in terms of exposure. Technical condition of suspension elements analysis and vehicle's operating parameters influence on the vibration in terms of human perception and exposure require identification of frequency component carrying most of the vibration energy. The results of time function of average vibration in chosen frequency bands presented in Chapter 9 represents very sensitivity symptom estimator. Almost in every investigated case the functions were totally separable in whole time domain. This function of exposure time to the vibration of defined frequency bands is sensible for vibration of the floor panel in location of driver and passengers feet. The developed functions S_t , $S_{T_{avr}}$ represent dominant dynamics components of vibration excited during most vibro-activity time of exposure and function of average value of time period vibration in frequency domain allow identify frequency components.

Second part of the book is focused on engine as source of vehicle vibration. In Chapter 11 the engine as vibration source was analysed. The structures of vibration occurring on different conditions of working engine expressed as rotational speed were presented.

Subsequently the identification of vibration propagation paths from engine into the occupants were presented. Basing on active experiments featuring measurements of vibration accelerations in a three directions in numerous selected points the analysis of propagation of vibration generated by engine to human body via feet and lumbar spine was conducted.

For the purpose of assessing exposure to vibrations of the overall impact on the human body by the vibration of the floor panel of the stopped vehicle with working engine the total estimators were proposed and compared in Chapter 13. Distribution of time energy floor panel vibration estimators RMS and S_{RMS} for different engine rotational speed shows that the energy estimators can have larger values for the smallest idle gear rotational speed. It is correlated to the feeling of vibration discomfort in the traffic jam, when engine is working on idle gear. To consider the influence on the dynamic of the vibration due to increase of the dynamic of the source the frequency estimators $T_{abs(FFT)}$ and $S_{T_{abs}}$ were described. The most complex analysis of influence of engine rotational speed on floor panel vibration can be conducted basing on TFR of the signals. Thus the method of TFR energy estimator was developed. It allows to calculate the estimator depends on time and frequency distribution of the vibration.

The next chapter presents results of investigation on the directional distribution of vibration exposed on driver penetrate via feet for different gear position in gearbox. The values of estimators of energy of vibration considered in time, frequency and TFR representation of the signal were collected and compared to value reached for neutral gear, without gear ratio.

Chapter 15 presents some results of identification of structure and directional distribution of vibration transferred to car-body from road roughness. The method proposed for identification of components of road irregularity induced vibrations for a moving vehicle may be brought down to comprehensive laboratory and road tests of the same vehicle while maintaining identical engine and power transmission operating parameters.

The issues of exposure to vibration in means of transport were discussed in Chapter 16. The chapter presents experimental approach to exposure to WBV penetrated through floor panel via feet into human organism. The different methods for evaluation were compared for assessment influence of vehicle technical condition and power transmission system on human exposure to whole body vibration. The analysis is concerned with the lumbar spine response. The calculation of acceleration dose and equivalent and daily static compressive stress S_e and S_{ed} for the assessment of health effects were done.

The phenomena of vibration propagation is related to dispersion of energy. Thus Chapter 17 presents research on dispersion of vibration energy in vehicle construction. The measures of vibration dissipation in automotive vehicles were defined and verified. They enable the vibration propagation and damping to be analysed and assessed by application of simple energy measures in the domains of time and frequency.

The final chapter of the book describes possibilities of application presented methods. The preliminary prototype experimental research were successful. The scope of research presented in the Chapter 18 included the tests of 2 modules for the chosen damping properties parameters. It enables developing the conception of the system for monitoring and control of comfort and safety of passenger cars is based on vibration signals analysis. The system was based on Vibroacoustic Signals Analyzer (WSA). The WSA program is extended with several modules dedicated to analysis, monitoring and diagnostics of selected vehicle systems and structural assemblies.