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**THE EXPERIMENTAL ANALYSIS OF INTERACTION VIBRATIONAL AND ACOUSTIC FIELD IN INTERIOR OF THE PASSENGER CAR**

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*The methodology of the experimental analysis of interaction vibrational and acoustic field of a system "man-machine-environment" of a complex mechanical-acoustic system are presented. Object of research is the modern middle class car of the set GAZ. The estimation of interaction of fields at road tests is made, influencing the different factors (motion on accelerating and steady conditions, road cover) is analyzed. At modal tests the analysis of interaction of fields is realized. The global vibration modes of the automobile and local vibration modes of panels, of a floor, roof, glasses and other subsystems are determined. The acoustic vibration modes in the car interior are determined. The formation of vibration frequency zones is analyzed. The approach to optimum tuning a mechanical-acoustic system is formulated and the recommendations on improvement of the vibrational and acoustical characteristics of the automobile are given.*

The researches of an internal noise and researches of vibration of a car construction are presented. There is an improvement of the standards on a noise and vibration in world automobile industry, on values which are determined an estimation and the degree of perfection and capability of exploitation of cars. Therefore there is an actual problem about creation and optimization of domestic automobiles up to parameters of a world level.

It is known, the noise penetrate into the car interior by two ways: by air and by transmit of vibration on a structure of the automobile. At research of an internal noise a structural noise transmitted on a construction of machines, and noise penetrating into the car interior by air, are considered as two separate noise sources. By the main sources, which one determine vibration and structural noise of the automobile are the engine, transmission, wheels, irregularity of a road. The noise, which one is transmitted in the car interior by air at closed windows is produced by acoustic radiation of outside surfaces of the engine, speed-box, rear end, aerodynamic noise, by a noise of an intake and exhaust system, by noise of an engine fan. Essential influencing on intensity of an air noise render the sound-absorbing and sound-tight characteristics of body materials, and also air-tightness of a automobile body.

The analysis of a mechanical-acoustic system "car" is realized in some stages. First stages is the road tests, at which one are determined real reactions at influence of real powers; second - modal tests, which one allow to determine absolute properties of a system.

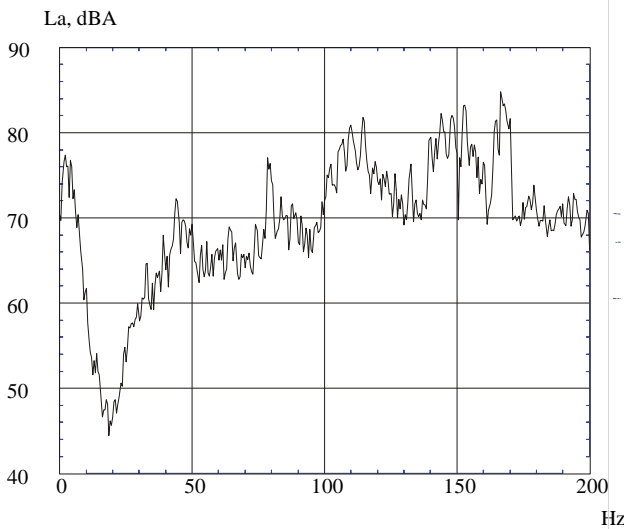
The aim of road tests is the definition of extreme points of a system, conformity to the requirements, definition of excitation sources and ways of penetration of a noise, thus are determined the maximum values of vibration in places of connection of a body with the main sources of vibration.

The road tests are carried out on standard technique: acceleration from 2000 rpm up to 0.9 max rpm on III and IV transmissions. The acoustic characteristics were measured by a sound level meter in two points of the car interior: at a level of a right ear of the driver and on back seat in center at a level of a head of the passengers. Were measured a general integral noise level on a linear scale - for an estimation of levels of an infrasound and noise level on a scale A. For realization of the analysis and detection of acoustic components which generate a general noise level, was used narrow-band spectral analysis. The researches have shown, that the integral noise level in the data points has compounded 77 dBA, that corresponds to the standard. The narrow-band spectral characteristic are shown in range 5...200 Hz on a fig. 1. The frequency components determining maximum of a noise are in frequency range of 100...180 Hz.

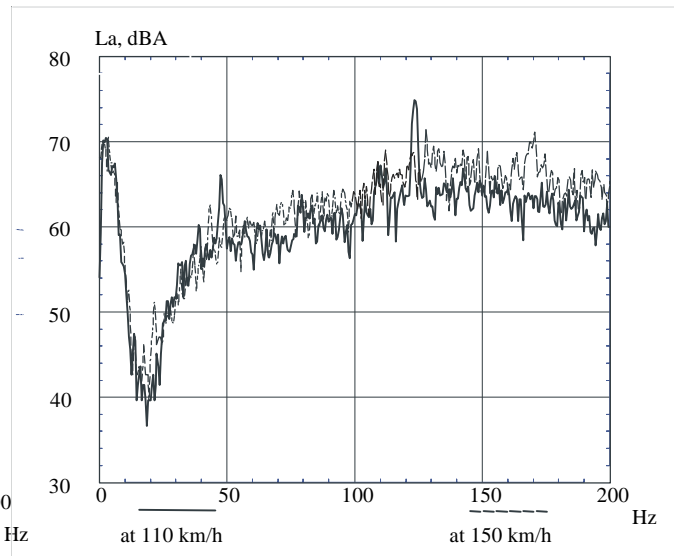
The accelerating characteristics are standard and allow to compare different automobiles Lack of the given kind of tests is that at acceleration it fails to evaluate a resonance-frequency behaviour of a system.

Therefore for more detail research the tests on steady conditions of motion of the automobile were made. This kind of tests was carried out on speeds from 70 up to 170 km per hour on IV and V transmissions. The typical spectral acoustic characteristics are shown in a fig. 2, where it is

possible to distinguish structural component of a noise and acoustic background. Also is detected, that with increase of a speed becomes more influential a noise penetrated by an air way.



**Fig. 1.** Spectral acoustic characteristic at an acceleration.



**Fig. 2.** Spectral acoustic characteristics at steady motion.

Quantity of measuring points both the vibrational characteristics, and acoustic, in road tests is limited and are determined in attachment points of the engine and transmission to a body and in points most vibrational subsystems (front wall, roof).

The modal tests allow to study own characteristics of a system and together with the previous kinds of tests allow to develop the recommendations and way of improvement of the ergonomical characteristics according to vibration and acoustic criteria. The modal tests allow to study only formation of a structural noise.

At modal tests an excitation source are the electrodynamic shakers. The tests allow to carry out vibrational and acoustic measurements in a lot of points (more than 1000 points on a construction). The global vibration modes were measured by the three-dimensional sensors, vibration mode of panels - the unidimensional sensors. During tests the frequency response characteristics of the system acceleration is estimated. It is relation of a signal of reacting to a signal of exciting force. On space of the car interior - 56 acoustic points. Such quantity of measured points enables to present vibrational and acoustic field, to define both frequencies and shape. The acoustic and vibrational transfer functions were analyzed in different kinds - module and phase, a real and imaginary part, Nyquist diagram, which one allow to define local and global resonance frequencies of a system.

The vibration frequency ranges is formed from interaction of global and local vibration modes of different elements of construction and finds reflection in acoustic properties of interior showing both at modal tests and at road tests.

The spectral acoustic characteristics of interior of the automobile were investigated in frequency range 5 ... 200 Hz. As a result of the analysis the frequencies of an air volume of the car interior are determined and is characterized by the brightly expressed resonance behaviour.

The comparison of road and modal tests has shown, that vibration frequency ranges coincide and coincide frequencies of an acoustic volume of the car interior, that indicates quality of the carried out researches and is detected, that the acoustic shapes interact with the shapes of mechanics and the acoustic shapes are determining for acoustic (see tab.)

Frequencies of road tests, Hz	Frequencies acoustic volume, Hz	Resonance inducing elements of a mechanical system of the automobile
	27.5	a body
	47.5	
	55.5	
76		a body, back glass, door
97	96	panels of a floor, front and back glass
101, 108		engine-frame
115	111	a drive unit, engine-frame, roof, front glass
123	120	a drive unit, rear end, panel of a floor
133	135	roof
153	153, 159	rear end, roof, glass of doors
163	163	rear part of a body, panel of a luggage compartment
179		front part of a body, engine-frame, panel of a floor
	189	

Thus methodology of research mechanical-acoustic system is to realize of road tests on accelerating and steady conditions, modal tests; detections of the global and local shapes, analysis of interaction of fields and obtaining " of a dynamic portrait ". The obtained data used for construction of mathematical model of a mechanical-acoustic system, where it is possible to optimize its dynamical characteristics.

As the recommendation for the further design of similar automobiles it is necessary to take into account, that the vibration shape of an acoustic volume should do not coincide with vibration modes of the car construction.

At increases of a speed of the automobile except a structural noise it is necessary to allow for a noise penetrating by an air way. Therefore problem should be decided completely: to affect a background and on structure.

In connection with composite nature of a sound field in the automobile and poor efficiency of computational method of testing the relevant value is gained by new experimental methods, for example, definition of vector of sound intensity describing distribution of an acoustic energy in a passenger saloon of the automobile.

#### REFERENCES

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