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CALCULATION AND EXPERIMENTAL RESEARCH OF STRUCTURAL NOISE OF ENGINE INTAKE SYSTEM VEHICLE

[a] Rakhmatdzhon Rakhmatov, [a] Vitaliy Krutolapov, [a] Givi Nadareishvili

[a] FSUE "NAMI", Moscow, Russia, rahmatov_ri@mail.ru

***Abstract**: The article presents a developed research procedure for structural noise of the motor vehicle intake system. A finite element model (FEM) of the inner and outer volumes of the body as well as its structure is developed. The calculation and experimental research results are given. The experimental validation of the calculation is performed.*

***Keywords:** Finite element model, intake system, shell noise, calculation and experimental research, experimental validation*

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1. INTRODUCTION

In recent years, the requirements for the external and internal noise of vehicles have been becoming more stringent. The input and output noise remains the main source of the running engine. This paper is devoted to the calculation and experimental research of the structural noise of the intake system, its main part – the air filter body – designed for intake of atmospheric air and installation of the filtering element. A finite element model of the air filter body with the outer and inner volumes was developed for calculation research of the structural noise [1-4].

The inner and outer acoustic volumes and structure consist of the first-order tetrahedral elements shown in Fig. 1.

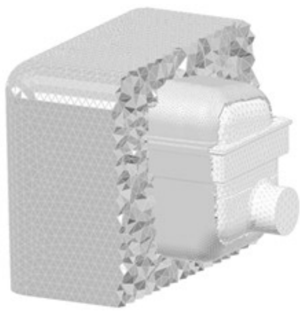

Fig. 1: Finite element model of air filter body

The boundary conditions were set for the gas-dynamic calculation:
1. Air flow of 0.2 kg/s at the inlet;
2. Free flow at the outlet.

For the vibro-acoustic task (structural noise research) with the maximum frequency of 5,000 Hz with 5 Hz pitch, the gas-dynamic calculation has been performed with the maximum calculation time of 0.2 s and the pitch of 0.0001 s with auto-saving of data of the velocity vector value and scalar values as follows: temperature, pressure, surface pressure, density, kinetic energy of the turbulent flow and acoustic velocity.

Boundary conditions for structural noise research:
1. Interpolation of all thermodynamic data of the gas-dynamic calculation of the air filter body inner volume to the inner volume and inner surface of the air filter body;
2. Fixing the air filter body according to the experiment;
3. Free channel modes at the inlet and outlet;
4. Infinite elements on the surface of the outer acoustic volume.

2. CALCULATION RESULT

The sound pressure distribution at 2,500 Hz is shown as an example in Fig. 2.

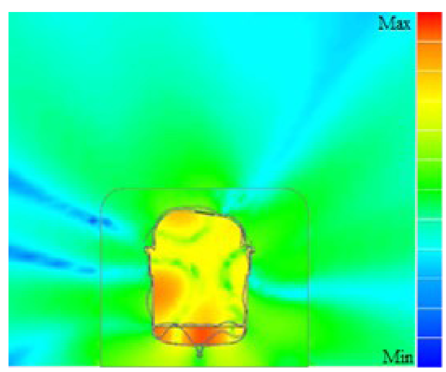

Fig. 2: Sound pressure distribution in section at 2,500 Hz

In order to assess the calculation research adequacy, experimental research was performed. The research was performed in the anechoic chamber shown in Fig. 3.

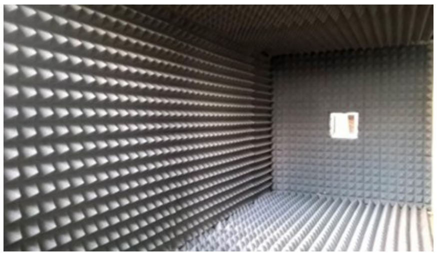

Fig. 3: Anechoic chamber

The air filter body is positioned in the middle of the anechoic chamber, the air filter body outlet pipe is connected to the axial fan providing air flow of 0.2 kg/s. The microphone was positioned 75 mm away from the air filter (body) cover (Fig. 4).

3. EXPERIMENTAL AND CALCULATION RESULTS

Fig. 4: Position of microphone and air filter body in anechoic chamber

The microphone was positioned 50 mm away from the surface of the air filter body.

Fig. 5 shows the results of the calculation and experimental research of air filter body structure-borne noise.

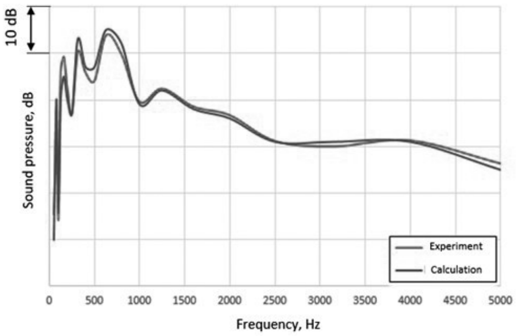

Fig. 5: Calculation and experimental research results

The analysis of the results of the calculation and experimental research of the air filter body shows that below 80 Hz there is a good correlation observed between the calculation and experiment, from 80 to 630 Hz the sound pressure peaks are at the same frequency but the amplitudes differ by up to 5 dB. From 630 Hz to 5,000 Hz the difference of the sound pressure amplitudes does not exceed 3 dB.

To minimize the calculation error it is necessary to carry out parametric optimization based on the sound pressure criterion; the material density and modulus of elasticity of the air filter body shall be used as a variable.

4. CONCLUSION

1. The finite-element model of the air filter body with outer and inner volumes was developed. The structural noise of the air filter body was calculated.
2. The experimental study of the air filter body structural noise was performed having shown the adequacy of the calculation studies.

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Rakhmatdzon Rakhmatov *is Ph.D. of Engineering Science, Lead of NVH department, State Research Center "NAMI". Rakhmatov Rakhmatjon is a specialist in calculation and experimental research NVH vehicle: Research on vehicle analogs in NVH, compiling target values from the level of components and systems to the level of the car assembly. Making tests program for vehicle. Compiling catalogs of target values. Drawing up plans for design and physical tests, etc. Planning, coordinating and control NVH testing and CAE analysis of vehicle (from components to systems). Calculations and experimental validation calculations: Modal analysis components, units, systems & BIW. Design optimization to remove from resonant frequencies; Vibration and noise transfer function analysis & local dynamic stiffness. Design optimization to improve vibration & acoustic isolation; Noise sources research: exhaust and intake systems, turbocharger (including noise when the bypass valve is open), cooling Fan. Design optimization to reduce sound pressure level (using active, constructive and passive methods). Radiation noise research: engine, automatic gearbox housing, air filter housing and etc. Design optimization to reduce radiation noise. Selection of noise absorbing and vibration-insulating material for vehicle panels. Aeroacoustics, including HVAC. Participation in tests, processing of experimental results, preparation of reports on results of computational and experimental research.*

Vitaliy Krutolapov *is Ph.D. of Engineering Science, Head of FEM modelling department, State Research Center "NAMI". Krutolapov Vitaliy is a specialist in calculation and experimental research NVH vehicle. Planning, coordinating and control NVH testing and CAE analysis of vehicle (from components to systems). Calculations and experimental validation calculations. Modal analysis components, units, systems & BIW. Vibration and noise transfer function analysis & local dynamic stiffness. Design optimization to improve vibration & acoustic isolation. Noise sources research: exhaust and intake systems, turbocharger (including noise when the bypass valve is open), cooling Fan. Design optimization to reduce sound pressure level (using active, constructive and passive methods). Research a new approach of modelling vibro-damping composires. Selection of noise absorbing and vibration-insulating material for vehicle panels.).*

Givi Nadareishvili *is Ph.D. of Engineering Science, Head of Antitoxic systems and noise suppression Department, State Research Center "NAMI". Nadareishvili Givi is a specialist in calculation and experimental research NVH vehicle. Planning, coordinating and control NVH testing and CAE analysis of vehicle (from components to systems). Calculations and experimental validation calculations. Modal analysis components, units, systems & BIW. Vibration and noise transfer function analysis & local dynamic stiffness. Design optimization to improve vibration & acoustic isolation. Noise sources research: exhaust and intake systems, turbocharger (including noise when the bypass valve is open), cooling Fan. Design optimization to reduce sound pressure level (using active, constructive and passive methods). Research a new approach of modelling vibro-damping composires. Selection of noise absorbing and vibration-insulating material for vehicle panels.).*