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Using of Multidimensional Massifs for the Determination of Noise Characteristics

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ABSTRACT *Using of multidimensional massifs for the determination of noise characteristics. The determination of noise characteristics is characterized by the recording of a significant volume of experimental data. For the calculation of sound power level are registered sound levels on an embraced surface, where the number of the measurement points can reach up to 20 at precise methods. The registering devices record the data with high frequency of scanning, and thus vectors with significant length are obtained. The using of multidimensional massifs shortens significantly the time necessary for the preliminary and subsequent processing of the experimental data.*

Introduction

The investigation of noise characteristics of motor-vehicle systems and assemblies is associated with the recording of a significant volume of values of the sound pressure. The length of the realized record at one measurement depends on several elements.

The speed of signal scanning for more devices is program determined. The speed has to ensure the determination of the amplitudes of harmonics of sufficiently high order, and to allow an execution of spectral analysis in the set range of frequencies. With these methods created for data processing, in order the calculations to be optimized, the scanning speed can be reduced at the recording of low-frequency noise and can be picked up if high-frequency components of noise spectrum are available. The obtained differences in vectors lengths at these speed changes are compensated during the process of determination of common signal limits and the limits of the elementary diagrams.

The sound power of the assemblies is determined by the assessment of noise intensity, which has passed through imaginary embraced surface. The level of such sound crossing this surface is measured in certain points. For the different methods in accordance of the characteristics of sound field and the measurement accuracy, the number of points can be 5, 8, and 10 for the tentative method, technical method and the precise methods for the determination of sound power levels, respectively. At all these points measurements of sound pressure at different frequency and load regimes of working of the examined object are done.

Presentation

The investigations of the possibilities of multidimensional massifs for simultaneous processing of recorded processes and the acceleration of calculations process is the goal of this study. The arrangement of these massifs precedes the preliminary processing of the experimental data [6]. A special attention should be brought to this process especially in respect to the vectors length on particular diagrams since the process determines the correctness of the further operations.

A point of the method

During the determination of noise characteristics the examined object works at set in advance regime of working. The number of these operation modes is different for the concrete examined objects, and depends on their characteristics. The sound pressure levels in the measurement points on the embraced surface are determined for each regime of working. The number of measurement points *j* is fixed, and depends on the properties of sound field and the method accepted for the measurement of noise. Because of a certain aperiodicity of signals the particular diagrams distinguish in vectors length with the experimental data. This difference in lengths reflects either upon sound pressure levels, or upon the harmonics amplitudes, especially of those in the low-frequency range. That is why, for the drawing up of massifs, it is necessary a few diagrams to be used, as in this case their number is 6.

The individual limits of massifs and the limits of elementary diagrams of the particular processes are determined. The definitions, presented in [6], are used as in this case the obtained vectors are arranged in a massif through additional cycles in respect to *j*.

$$
\begin{aligned}
\mathrm{diag} := \ & \text{for } j \in 1..\mathrm{last}(M)\\
& \quad \mathrm{diag}_j \leftarrow 0\\
& \quad \text{for } i \in 0..\mathrm{rows}(M_j) - 31\\
& \quad \quad \mathrm{diag}_j \leftarrow \mathrm{diag}_j + 1 \ \text{ if } (M_j)_{i,2} > K\gamma \wedge (M_j)_{i+1,2} < K\gamma \wedge (M_j)_{i+\sigma,2} < K\gamma\\
& \quad \mathrm{diag}_j \leftarrow \mathrm{diag}_j - 1
\end{aligned}
\tag{1}
$$

This indicator determines the number of processes which are subject to processing. It can be changed if a significant unevenness in cycles is available, or if it is necessary for the goals of the statistic processing of signals.

The massif *Index* is forming and is used for the identification of the elementary cycles. This massif contains the elementary cycle limits according the index of the basic massif for all processes and particular diagrams in it. The initial and the final values in it determine the limits of the periodical cycles of the recorded processes.

$$
\begin{aligned}
\mathrm{Index} := \ & \text{for } j \in 1..\mathrm{last}(M)\\
& \quad p \leftarrow -1\\
& \quad \text{for } i \in 0..\mathrm{rows}(M_j) - 2\\
& \quad \quad p \leftarrow p + 1 \ \text{ if } (M_j)_{i,2} > K\gamma \wedge (M_j)_{i+1,2} < K\gamma \wedge (M_j)_{i+\sigma,2} < K\gamma\\
& \quad \quad \mathrm{index}_{p,j} \leftarrow i \ \text{ if } (M_j)_{i,2} > K\gamma \wedge (M_j)_{i+1,2} < K\gamma \wedge (M_j)_{i+\sigma,2} < K\gamma\\
& \quad \mathrm{index}
\end{aligned}
\tag{2}
$$

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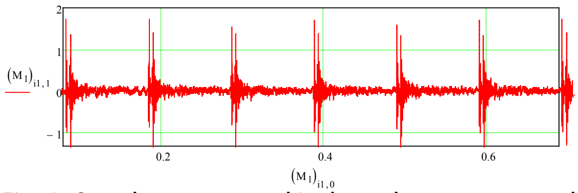

Fig. 1. Sound pressure graphic dependence represented in dimensionless form in one measurement point

The sound pressure graphic dependence for 6 cycles from the signal registered in one measurement point for one frequency operation mode is presented in Fig. 1. The massif *Index* contains the final and current limits of the elementary cycles.

The effective quantity of sound pressure is determined from programming cycle (3) for each elementary period of the recorded signals in the measurement points.

$$p_{ef} := \text{for } j \in 1..\text{last}(M)$$
$$\quad \text{for } q \in 0..\text{diag}_j - 1$$
$$\quad\quad p_{ef_{q,j}} \leftarrow \sqrt{\frac{1}{Index_{q+1,j} - Index_{q,j}} \cdot \left[\sum_{i = Index_{q,j}}^{Index_{q+1,j}} \left[K_{druck} \cdot (M_j)_{i,1}\right]^2\right]}$$

(3)

The index *q* is the number of the consecutive diagram of the measured signals in the multidimensional massif M. This index is the same for all measurement points *j*, and identifies the *q*-diagram from the massif *M*. The summation of data is done up to the elementary diagrams limits of the massif *Index*. The comparison of the quantities of the effective magnitude of sound pressure during consecutive cycles can serve for the assessment of the presence of outer background noise caused by the work of different machines and equipment associated with the insurance of normal operation conditions of the examined unit. The presence of reflected waves in the sound field engendered by the room reverberation leads to the appearance of harmonics with different period as in this way they deform strongly the direct sound signal. The significant derivations in the effective quantity of sound pressure on consecutive diagrams cannot be explained with the periodicity of the processes in internal combustion engines and the systems associated with them. It is necessary, in these cases, to be carried out actions for the isolation of the non-characteristic sound signals in order the reverberation in the measurement space to be reduced, and the conditions for the measurement in free sound field to be improved.

The level of sound pressure in the *j*-measurement point for *q*-diagram is determined by the expression:

$$Ls_{q,j} := 20 \cdot \log\left(\frac{p_{ef_{q,j}}}{p_0}\right) + PC$$

(4)

The quantities of sound pressure level in the massif $Ls_{q,j}$ are presented in [dB]. PG is the threshold value of the attenuator of sound pressure amplifier.

The massif with frequencies of the elementary diagrams is determined by programming cycle (5).

$$f_q := \text{for } j \in 1..\text{last}(M)$$
$$\quad \text{for } q \in 0..\text{diag}_j - 1$$
$$\quad\quad f_{q_{q,j}} \leftarrow \frac{1}{(M_j)_{Index_{q+1,j},0} - (M_j)_{(Index_{q,j}),0}}$$

(5)

The massifs $Pef_{q,j}$, $Ls_{q,j}$ and $fq_{q,j}$ have zero values in columns *j=0*. In this case the using of only direct operators for determination of mean matrices quantities leads to a significant incorrectness in results. That is why transposed vectors of the form $\text{mean}\left(f_q^{\langle j\rangle}\right)$, or only non-zero elements from the matrices have to be used. The correct values of the mean quantities of frequency of the elementary diagrams in the measurement points of sound without values in the zero-column are determined after the following transformation:

$$X_{j-1} := \text{mean}\left(f_q^{\langle j\rangle}\right) \quad (6)$$

The frequency of periodical elementary diagrams in the measurement points depends on the operation modes and the characteristics of the examined object. For noise characteristics of gas-electromagnetic valves, and in other cases when the operating impulses are feed by signal-generators, the frequency of the mechanical signals is considerably constant, and in practice does not change from cycle to cycle. During the test of internal combustion engines the change of frequency by cycles depends mainly on the degree of unevenness of engine operation and can be used as a criterion for an assessment of this indicator.

The frequency of signals scanning along with the length of the recorded vectors during the using of multidimensional massifs can be different at data registration in particular points of sound pressure measurement. This allows the single signals to be individually processed in the consecutive calculations in the programme cycles. Such change can be executed with the purpose of optimization of the experimental study, especially during the registration of low-frequency processes, in which the experimental data create vectors with significant length. At some low-frequency processes the length of massif with data reaches the values of 2^{18}, that holds up strongly the calculations and loads up the processors, especially in the part concerning the harmonic analysis. The frequency of scanning is determined for each process in measurement points according to the expression (7):

$$f_{sk_j} := \frac{1}{\left[(M_j)_{1,0} - (M_j)_{0,0}\right]}$$

(7)

For the correct consecutive reading of data and processing with the massif is necessary the structure of the integrated massif to be known.

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Conclusion

The determination of noise characteristics of elements and assemblies in motor-vehicles is done with methods requiring a measurement of sound pressure in different points on the embraced surface. The number of these points is significant. The levels of sound power are determined as a rule at nominal operation modes of the examined object, but in necessity some measurements are done during other characteristic operation mode. The processing of such large massifs of data requires a significant resource of time and computer facilities.

One way for reducing the time for data processing and increasing the possibilities for analysis of the results is the using of multidimensional massifs. During their using the mass of variables transform in vectors, while the vectors are arranged in massifs. The transition to such methods of data processing requires compulsory using of programme cycles.

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