THE COHERENCE METHOD OF TECHNICAL STATE EVALUATION COMBUSTION ENGINE

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Abstract

The actual tendency to develop methods end techniques to diagnostic vehicles is making grow the interest and the demand of the technical state analysis in exploration conditions, besides to systems, machines and devices more and more complex. The problem whit design and exploitation of modern machines and technical devices is to recognize the technical state in operational conditions [1-4]. To define the correct dynamic model and choose the best research method is the question of industry field, and the present paper has an approach about this topic.

The coherence function which is the local measure of the similarity processes has, so the essential diagnostic properties in the reference to the objects which carry I will name linear and stationary in the field of the dynamic time. Yet the larger possibilities of uses of the diagnostic coherence functions can to find in mechanical arrangements non-stationary or non-linear.

The present methods of the diagnosing the condition of the folded objects combustion engines are which, are based on the measurements of the value steering currents. The vibrodiagnostic of combustion engines is the using analysis vibration processes generated in combustion engines the alternative method. Vibrodiagnostic enabling the opinion of the engine condition using the sensibility estimate the vibration process [1, 7-10].

The estimation of the combustion engine condition with sparkle ignition for the help of the research of vibration measures is possible thanks to utilization to the property of the coherence function [5, 6].

The implementation of software for needs: the acquisition of vibration processes, their processing, statistical inference and visualization - facilitates the leadership of investigations and the study of results.

Keywords: *combustion engines, coherence function, vibrodiagnostic*

1. Introduction

Researches relative to vehicles diagnostic and the focus around following investigative problems in the peculiarity of piston combustion engines for the help of the vibration process [7]:

- the analysis of vibration processes for sorted temporary sections connected with the period of the ignition for the control of burning process in the engine;
- the temporary and ghostly selection of vibration on process to the control of the technical states the mechanical elements in the engine;
- the investigation of the changing factors on the value of the diagnostic parameters of the vibration process - the engine technical state, exploational and constructional factors, appearing near every investigation vibrodiagnostic.

2. The property of the coherence function

The function of coherence defined as follows is measure cohesion between two vibrodiagnostic processes *x(t)* and *y(t)* about outlined previously properties [2]

$$\gamma_{xy}^2(f) \equiv \frac{\left|G_{xy}(f)\right|^2}{G_{xx}(f)G_{yy}(f)}. \tag{1}$$

The model of obtainment the coherence function in diagnostic combustion engine is shown on Fig. 1.

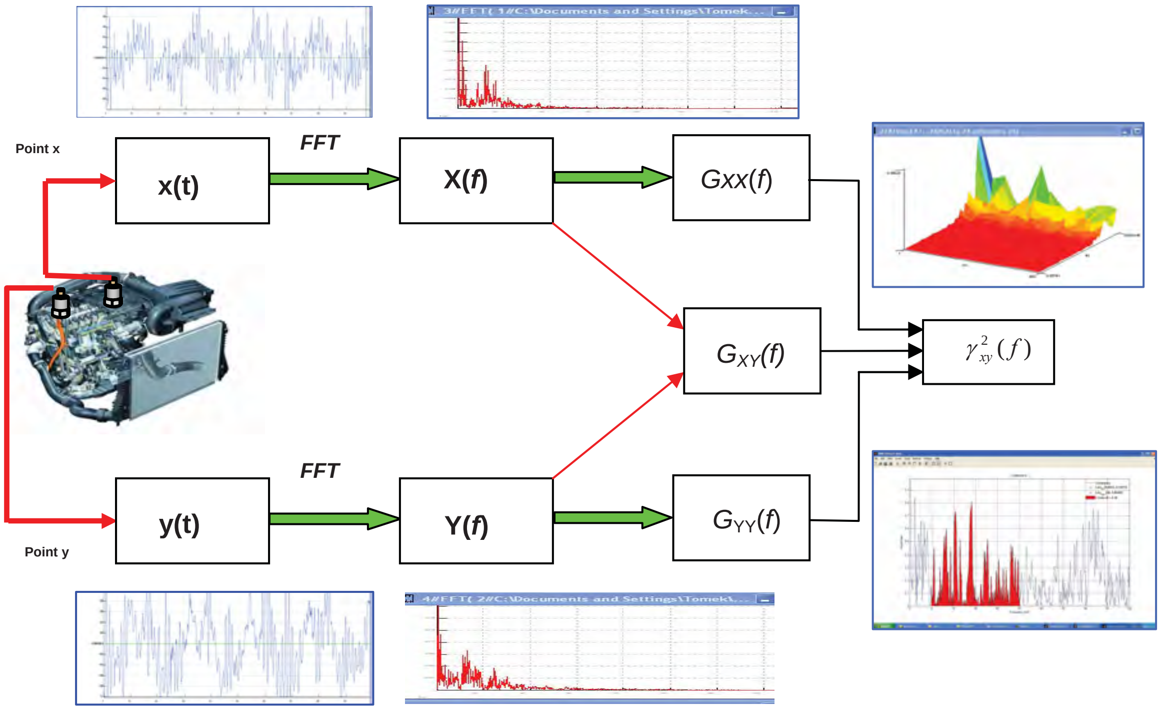

Fig. 1. The model of obtainment the coherence function in diagnostic combustion engine

Counting ghostly thicknesses for the passed higher example we, in the function of the thickness the source process at time and well-known transfer function estimation $h_1(f)$, $h_2(f)$, receive:

$$\begin{aligned} G_{xy}(f) &= h_1(f)h_2^*(f)G_{uu}(f), \\ G_{xx}(f) &= |h_1(f)|^2 G_{uu}(f), \\ G_{yy}(f) &= |h_2(f)|^2 G_{uu}(f). \end{aligned} \tag{2}$$

We get:

$$\gamma_{xy}^2(f) = \frac{|h_1(f)h_2^*(f)|^2 G_{uu}^2(f)}{|h_1(f)|^2 G_{uu}(f) h_2(f)^2 G_{uu}(f)} \le 1. \tag{3}$$

The values of the coherence function can change in borders from 0–1.

$$0 \le \gamma_{xy}^2(f) \le 1.$$

Now, independently from transfer function estimation roads character of the passage, the coherence function always accepts the value one if only the signals $x(t)$ and $y(t)$ come from the same sources. For the larger number of sources than one or with the moment of appearing, any damage the coherence function is non-negative that is always smaller than the unity. The also turn the special attention on the sensibility of coherence on the location of damages.

One can affirm that coherence function as measure of cohesion between two signals have a good diagnostic properties from above mentioned conclusions, because appearing the signal of new damage violates cohesion that is why the coherence function diminishes previous.

This function can be used to the inference about rooms in new rolling bearings on the basis of the coefficient of coherence between strength extorting, and vibrations received on the external track. The ability of the coherence function to the discrimination of rooms can be completely sufficient to the aims of the diagnostics [4].

The use of the coherence function in the diagnostics does not restrain to the cases of straight lines from one the dear passage, but he equally useful is in the situations of the propagation vibrations or the noise.

The coherence function which is the local measure of the similarity processes has, so the essential diagnostic properties in the reference to the objects which carry I will name linear and stationary in the field of the dynamic time. Yet the larger possibilities of uses of the diagnostic coherence functions can to find in mechanical arrangements non-stationary or non-linear.

The newest example from this last field this detecting the rooms in the steams of kinematics mechanisms or machines [3], what the use has near the opinion of the rooms of bearings in the peculiarity [1, 4].

3. The research method

The research how changing value of coherence function for chosen characteristic frequencies and the value of ghostly thicknesses (the correlation of vibration processes) and transfer function estimation (the function of the passage) together with from estimation of the size of the field under crooked got in the computer system of identification investigations SIBI, on the opinion change the technical state of the engine possible thanks to the proposed investigative method. Method this hugs the realization of measurements got in the figure, of temporary courses. Then analyses in the aim of the obtainment of exchanged measures with the programme SIBI.

Fig. 2. The research method

To the analysis possible is using tools to enabling the inference causal - consecutive inference and multidimensional glance on the folded object e.g. the combustion engine (OPTIMUM, SVD, regress …).

4. The results of research

The investigations object was a combustion engine No. 138C.2.048 with 1.4l. swept capacity, power 55 kW / 75 KM, generally applied in Fiat Uno 75i.e (see Fig. 3). Combustion engine was situated in the investigative laboratory of combustion engines in UTP Bydgoszcz.

On the object of research being in the laboratory - simulate 33 the states which answered the damages of spark plug and injectors on the individual cylinders of engine and the combination of these damages.

During experimental research in the aim of the obtainment, uniform in the time conditions in the exploitation engine following guidelines:

- 830 r.p.m was executed measurements for the rotatory speed of the engine,
- for neutral gear - temperature of the trunk of the engine carried out 71 degrees ,
- the dynamic state of the engine is described 30 measuring files,
- the investigations- were executed with utilization of two measuring channels, what the fulfilment of the condition of Fourier transformation.

Fig. 3. The object of investigations

The measuring track consisted from:

- two sensors ICP Accelerometers the model HTM,
- two cables of standard series 002 among sensors in the entry of the card In 4, In 1.

They became measured and processed signals in the figure: TIME - the time response of the signal VIBDAQ.

However from attention on the large quantity of the data and the format of the publication, he will be introduced become only introduction of the possibility of the programme SIBI (see Fig. 4) with enable:

- Module A - import UNV format (see Fig. 5),
- Module B - build the matrix of symptoms (see Fig. 6) to use for a get a estimate of vibration process,
- Module C - Input – Output relationship functions (see Fig. 7) is the most important part of this program. In this application we make get a data which we need for coherence function analysis,
- Module D - OPTIMUM procedure (see Fig. 8),
- Module E - Singular Value Decomposition (see Fig. 9),
- Module F - Regress.

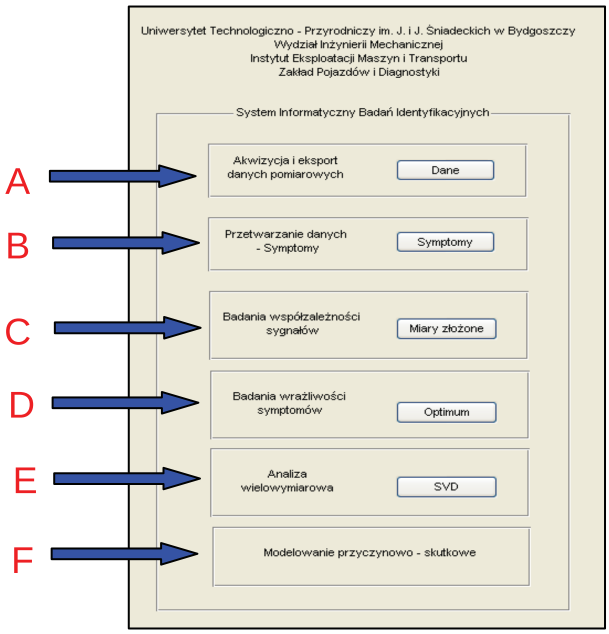

Fig. 4. SIBI main window

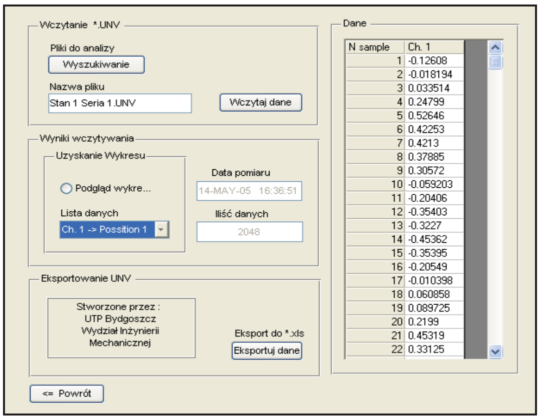

Fig. 5. Module A

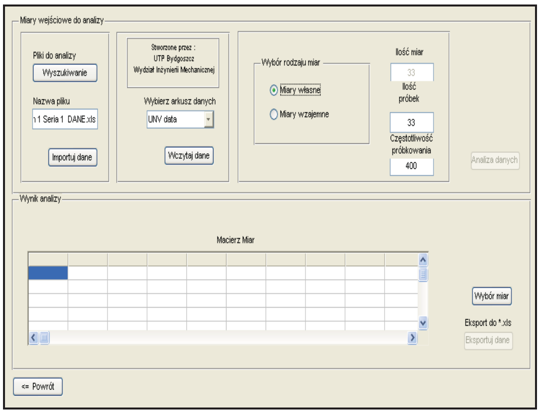

Fig. 6. Module B

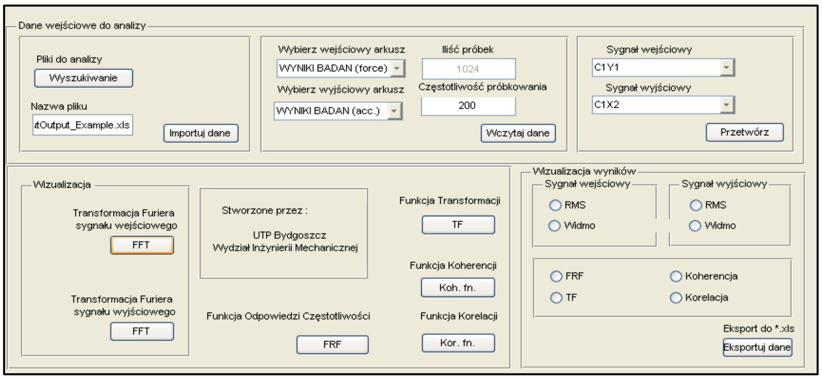

Fig. 7. Module C

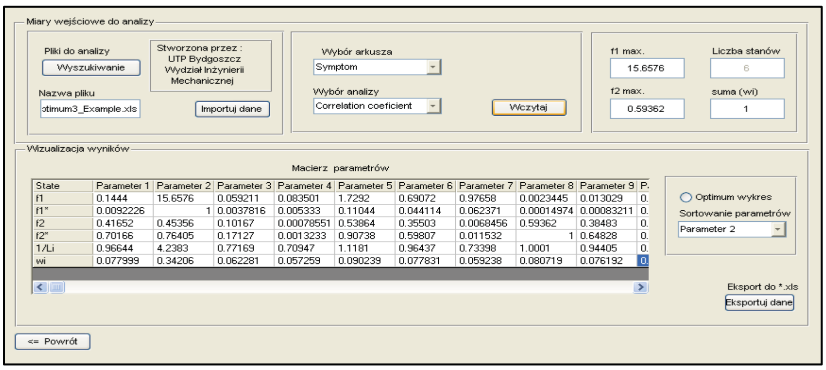

Fig. 8. Module D

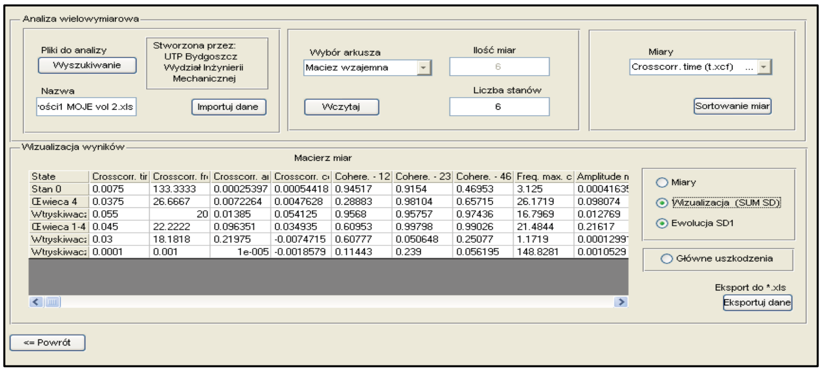

Fig. 9. Module E

The technical state of the research object it was verified through own symptoms and related. The final observation matrix of engine performance given described 18 own symptoms generated in SIBI - module B and 15 related symptoms generated in SIBI - module C include function coherence [10].

Figure 10 presents the graphic interpretation of the engine state analyses with damaged of shine on fourth cylinder.

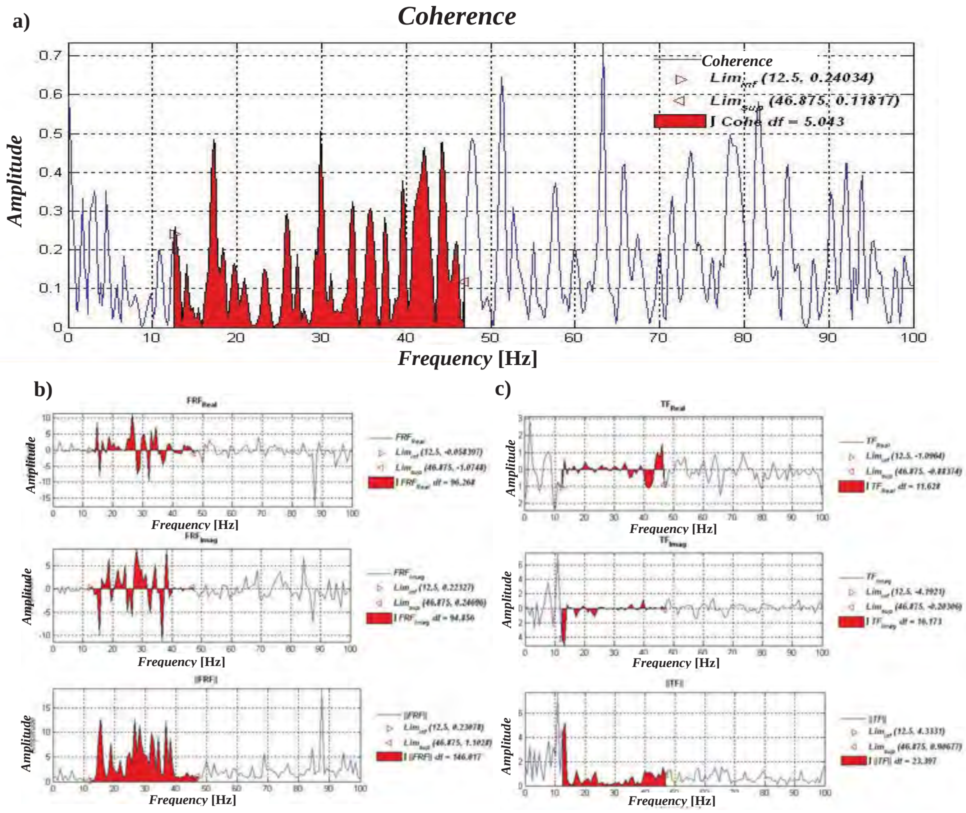

Fig. 10. The graphic interpret ation of the analys e engine state with damaged they s hine on fourth cy linder: a) the coherence function, b) the FRF function, c) transmitancion function (the analysed area was marked the red colour)

Taking into account their diagnostic sensibility the method of THE OPTIMUM let on the in a row of symptoms. Diagrams for related symptoms were showed on Fig. 11 and for own on Fig. 12.

The multidimensional analysis of the qualitative and quantitative opinion of the measures diagnostic signals was based about the method SVD. The results of analysis for related symptoms (see Fig. 13) and own symptoms (see Fig. 14) they let on the indication of best symptoms describing the technical state of the engine.

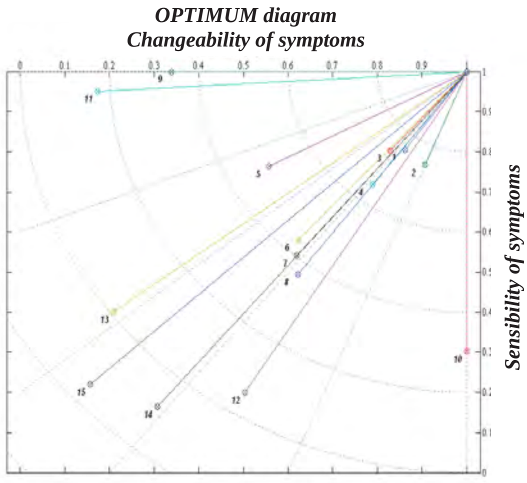

Fig. 11. Diagram OPTIMUM for related symptoms

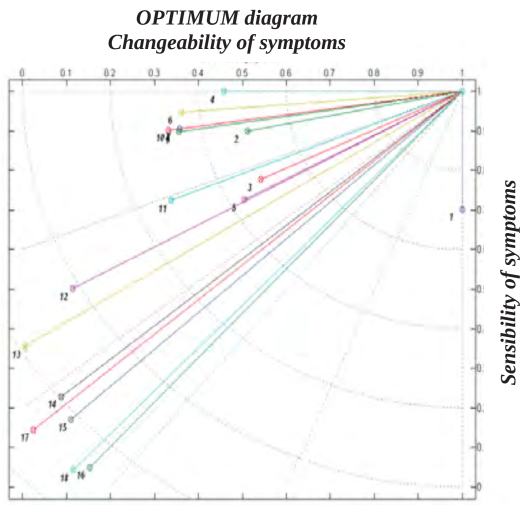

Fig. 12. Diagram OPTIMUM for own symptoms

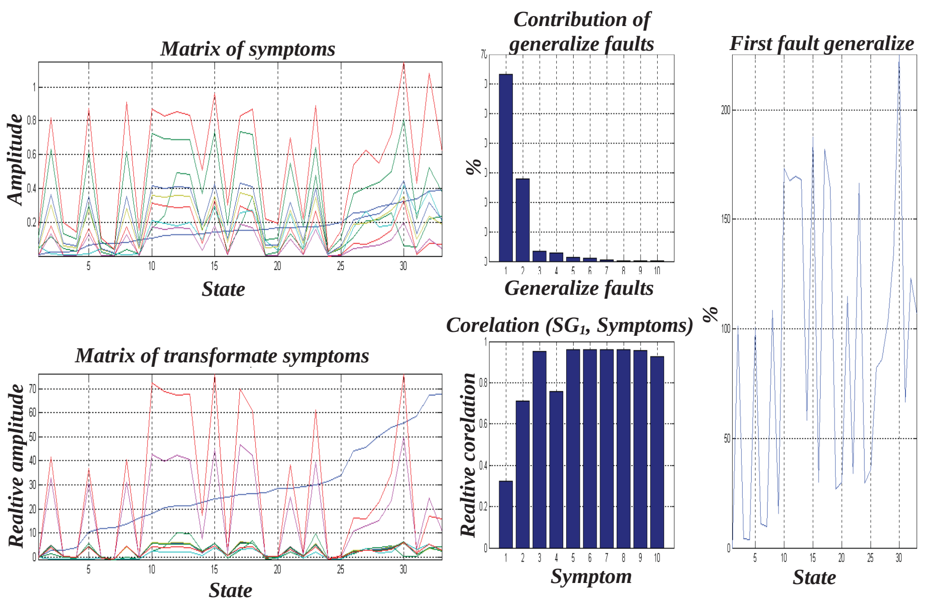

Fig. 13. The graphic interpretation of the analysis the method SVD for own symptoms

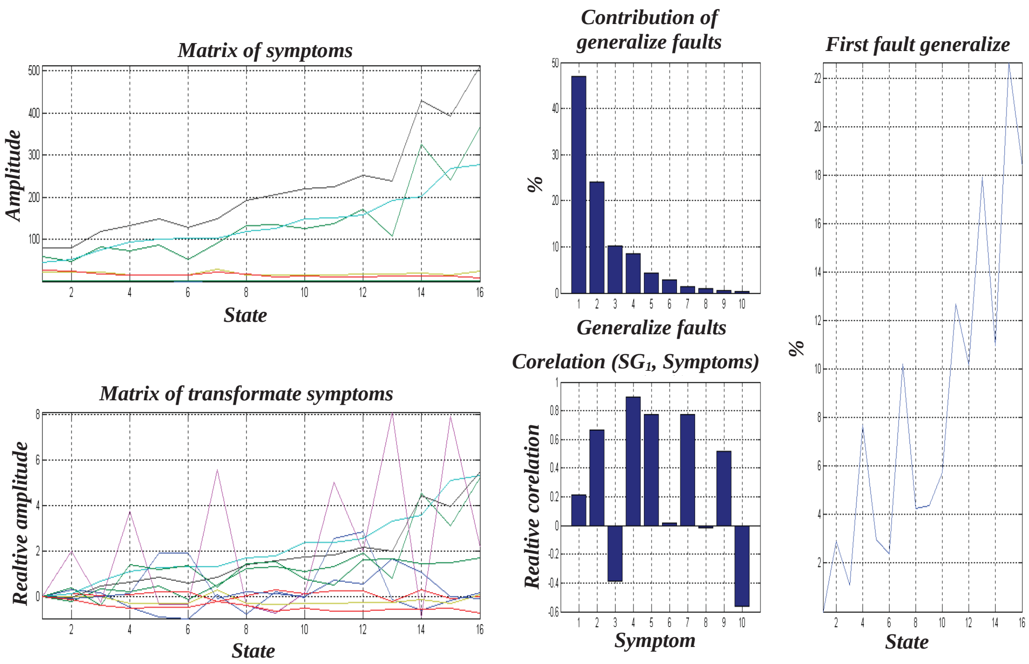

Fig. 14. The graphic interpretation of the analysis the method SVD for related symptoms

The analysis the method SVD showed how large is the part of symptoms connected with the coherence function. This let on using the property of the coherence function in the diagnostics of combustion engines.

The study of the regress define the relationships between classified for results of the investigations of this work through utilization the property of the multiple regress function from the attention was studied changing this become he the folded character of the investigations object and the large quantity of parameters describing the technical state of the combustion engine.

5. Conclusion

The present methods of the diagnosing the condition of the folded objects combustion engines are which, are based on the measurements of the value steering currents. The vibrodiagnostic of combustion engines is the using analysis vibration processes generated in combustion engines the alternative method. Vibrodiagnostic enabling the opinion of the engine condition using the sensibility estimate the vibration process.

The estimation of the combustion engine condition with sparkle ignition for the help of the research of vibration measures is possible thanks to utilization to the property of the coherence function.

The implementation of software for needs: the acquisition of vibration processes, their processing, statistical inference and visualization - facilitates the leadership of investigations and the study of results.

Relationships cause - consecutive expressing quantitative relation between studied variable symptoms results were qualified using the function of the multiple regression.

The analysis of research results showed how large is the part of symptoms connected with the coherence function. This let on using the property of the coherence function in the diagnostics of combustion engines.

The introduced in these paper results of investigations are only the part of realized investigative project and they do not describe wholes of the investigative question, only chosen aspects.

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