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MULTIVECTOR DIFFERENTIAL CONVERTERS OF VIBRATION INFORMATIONS MEASURING SYSTEM

In article suggests statistical model as model of refusals of served elements on the basis of DN-distribution is offered. Researches are made in a mode of modeling of maintenance service „on a condition" with constant periodicity of the control. By results of the lead researches the general reason that the less size of factor of a variation of a casual operating time to refusal of served elements, the great should be optimum value of a level of maintenance service proves to be true.

Keywords: *factor of the variation, served elements, value of a level, maintenance service.*

Introduction. Tenzoresistive gauges represent an elastic element on which it is fixed tenzoresistor. Such gauges are widely enough applied in measuring techniques. Under action of force (weight of a cargo) there is a deformation of an elastic element together with tenzoresistor. On change of resistance tenzoresistor it is possible to calculate a degree of deformation which is proportional to the force applied on a design. At use of several such converters there is an opportunity of reception of the information, for example, about a degree of deformation in different places of a detail or to investigate a degree of vibration of complex rotating mechanisms. Such researches allow to remove the characteristic, to investigate a degree of deterioration of elastic and rotating elements, allow to define probability of their refusal or another [1, 2].

The principle measurements of parameters vibration by means of strain gauges is based on definition of the characteristic of the primary converter which, as a rule, is rigidly fixed on the information gauge. Last alters vibrating fluctuations in inertial movement of the mechanical device more often beam type. The size of this force is proportional to change of geometrical parameters, namely - curvature балочного an element. So we have primary transformation of not informative type. The purpose of the further transformation will be reception on an output of the gauge of the measuring information convenient for the further transfer and processing. Such information converter, also it is applied tenzoresistive an element which makes the further transformation of a degree of curvature into respective alteration of resistance tenzoelements. For the further processing such information there is enough inclusion tenzoresistor in an electric circuit, for example, the operational amplifier, both the further transfer and processing of the information. Depending on external conditions and the declared characteristics sensitive elements can be and other type. So greater sensitivity is added to the gauge of vibration with pezo-converters, but they have greater problems at removal of the information and at their accommodation.

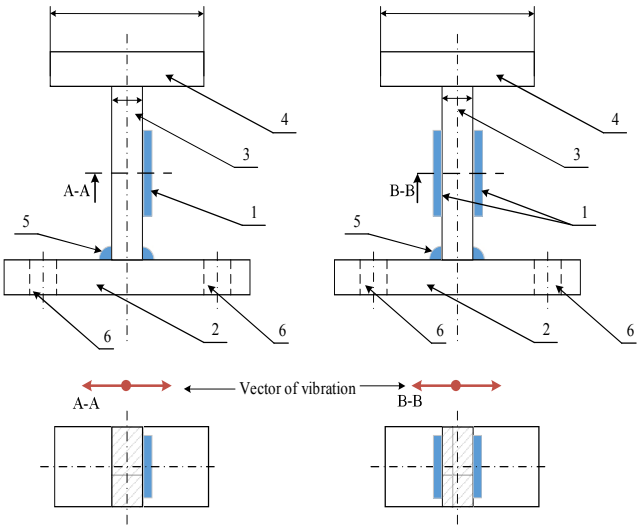
Basic part. On the basis of a principle of work of weight gauges, have found the application - vibrometr, that is devices for definition of parameters of vibration. As such parameters the amplitude and frequency of vibration act first of all. In the most simple kind, the device for reception of these two parameters is shown on fig.1, and [1, 2, 4].

Feature of this device is removal of the characteristic of vibration in one direction. For change of a direction moving all gauge to a place of fastening of the basis 2 is necessary. For this purpose often apply прорези 6 to fixing bolts in the basis in the form of sector of a ring. As lack of such device enough greater mistakes for an exact choice of an adjusting direction – a vector acts. Other lack of such systems is complexity of reception of a straight-line characteristic tenzoelements for different amplitudes of fluctuations [5].

Feature of this device is removal of the characteristic of vibration in one direction. For change of a direction moving all gauges to a place of fastening of the basis 2 is necessary. For this purpose often apply aperture 6 to fixing bolts in the basis in the form of sector of a ring. As lack of such device enough greater mistakes for an exact choice of an adjusting direction - a vector acts. Other lack of such systems is complexity of reception of a straight-line characteristic tenzoelements for different amplitudes of fluctuations [5].

For reception of a signal as the primary converter the beam 3 rigidly fixed on the basis of vibrogauges 2, for example, by means of welding 5 is used. Thickness of a beam gets out at the rate of predicted amplitudes and frequencies of vibration. On the free end of a beam the balance weight 4 is rigidly fixed. The sizes and weight of the balance

weight get out as at the rate of prospective characteristics of vibration, and, having a set of balance weights there is an opportunity of management of a range of characteristics of the vibrator. On a beam it is attached tenzoconverter 1 for definition of changes of geometrical parameters as a result of fluctuation of a beam.



1 – tenzoconverter; 2 – basis; 3 – beam of the vibrator;
4 – balance weight; 5 – place of fastening (welding); 6 – aperture for fastening

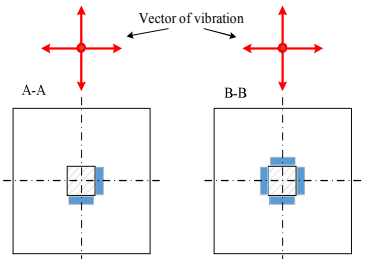
Figure 1 – Vibrogauge with tenzometric the converter: a – with one tenzoconverters;
b – with two, symmetric tenzoconverter

For linear characteristics of the converter the device for balancing mechanical devices with linear the initial characteristic, fig. 1, b is offered. Distinctive feature of this device is that two strain gauges 1 are fixed symmetrically, on the different parties of a beam 3. Both devices, shown on fig.1 have an opportunity to react to vibration only in one direction, that is in our case along a horizontal axis of symmetry (see a cut A-A and B-B fig. 1).

Often there is a necessity of reception of the characteristic of vibration in different (a lot of vector) directions. For reception of signals about vibrations in a perpendicular (cross-section) direction it is enough to choose section of a beam in the form of a square and to attach symmetric tenzoconverters on opposite sides, as shown in fig. 2. As for reception of identical signals about vibrations application of the symmetric balance weight 4 (see fig.1) is necessary.

Such way of measurement can be defined as differential therefore as in the further it is necessary to use constantly only the generalized information from the offered gauge. Such way solves one more important problem. It linear characteristics of the gauge practically in all its working range.

Earlier for this purpose use of additional devices or circuit decisions was offered. Here there is an opportunity of reception of a straight-line characteristic after the first transformation.

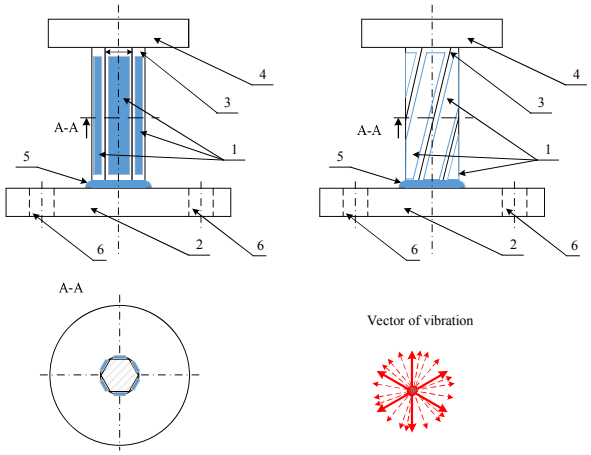


a) object Test-1 b) object Test-4

Figure 2 – A kind vibrogauges (see fig.1) with symmetric tenzometric the converter:
a – with two tenzoconverters; b – with four, in pairs symmetric tenzoconverters

Such way will allow simplifying considerably the further schemes of processing of the information, and owing to it to reduce methodical errors. Also, use of a case when the beam can be in the form of the overwound hexagon on which each side is interesting are fixed tenzoconverters, that allows to spend measurement more precisely.

Besides, the step скрутки should be equaled to width of one side. At such arrangement tenzoconverters and the system approach to съему from them the information, the opportunity with identical accuracy of removal of indications vibrogauges practically any direction – vector it is lot (see fig. 3) is received.



1 – tenzoconverters; 2 – fastening; 3 – six sides beam of the vibrator (a); 4 – balance weight; 5 – place of welding; 6 – aperture for fastening; 7 – beam of the multivector vibrator (b) is curtailed six sides

Figure 3 – Vibrogauges with tenzometric the converter on a beam six sides type

Tenzoconverters should have the symmetric characteristic. For this purpose we shall receive mathematical model tenzoconverters. We shall receive the linear equation and approximation of the sixth degree [3] further.

The equations for tenzoconverters look like:

Linear:

$$y = 1888573,46 \cdot x^{-5558,63}. \quad (1)$$

Polynome:

$$y = 4x \cdot 10^{-14} \cdot x^6 - 3x \cdot 10^{-11} \cdot x^5 + 2x \cdot 10^{-8} \cdot x^4 + 10^{-7} \cdot x^3 + \\ +0,0017x^2 + 0,6992x + 196,82, \quad (2)$$

where x - a variable of moving (vibration)

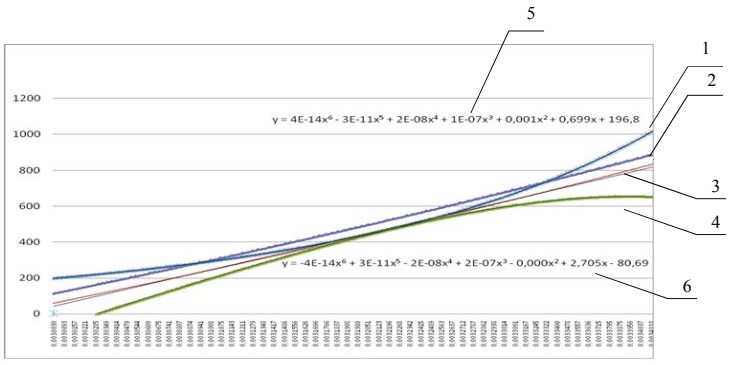
For reception of the symmetric characteristic it is necessary to define the maximal mistake of linear approximation then it is received the linear equation with displacement on the established mistake. Practically it leaves model of the symmetric gauge which will differ from real only on a mistake of inconsistency of pair gauges.

Further we receive a difference between values at polynome approximations and the displaced straight line, increasing each mistake twice we shall receive a line symmetric to a line of the first gauge.

Let's deduce it polynome approximation of the sixth degree. The equation of mathematical model tenzoconverters, connected in a parallel looks like:

$$y = 4x \cdot 10^{-14} \cdot x^6 + 3x \cdot 10^{-11} \cdot x^5 - 2x \cdot 10^{-8} \cdot x^4 + \\ +2x \cdot 10^{-7} \cdot x^3 - 0,0007x^2 + 2,705x - 80,694. \quad (3)$$

On fig. 4 the schedule of all functions of the mathematical analysis of characteristics tenzoconverters is shown.



1 – Schedule tenzoconverters; 2 – Linear approximation of the characteristic tenzoconverters; 3 – Moving of a line 2 on distance of the maximal absolute error; 4 – Schedule of function for the symmetric converter; 5 – Mathematical polynome the equation of the first tenzoconverters; 6 – Mathematical polynome the equation of the symmetric converter

Figure 4 – Characteristics symmetric tenzoconverters on a beam

Conclusions. The lead analysis of materials has shown, that there are unresolved questions of research and reception of the information on characteristics of vibration in several directions. System application of the gauge of vibration of the offered type allows to conduct multivector research in a mode of real time, and at the same time to define vibrating characteristics in the basic directions of vibrating fluctuations, and to define collateral vibrations which often carry out harmful actions in work of object which is investigated. In work results of a mathematical substantiation of such researches are shown. Using the modern software of personal computers it is easy to reproduce range of vibrations of investigated object.

References

1. Информационно-измерительная техника и технологии: учеб. для вузов / ред. Г.Г. Раннева. – М.: Высшая школа, – 2002. – 512 с.

2. Раннев Г. Г., Тарасенко А. П. Методы и средства измерений: учеб. для студ. высш. учеб. заведений. – М.: Издательский центр «Академия», – 2008. – 336 с.

3. Лещенко О. І. Методи вимірювання параметрів вібрації / О. І. Лещенко, І. Ю. Садковська, І. А. Зборовська // Технічне регулювання та якість: сучасний стан, проблеми і перспективи: матеріали П'ятої Всеукраїнської науково-практичної конференції молодих учених і студентів. Одеса, 20-21 травня 2014 р. – Одеса: ОДАТРЯ, 2014. – С. 162-163.

4. Фрайден Дж. Современные датчики: справочник / Дж. Фрайден. – М.: Техносфера, 2005. – 152 с.

5. Аркуша А.И. Техническая механика: Учебник для машиностроительных специальностей техникумов / А.И. Аркуша, М.И. Фролов. – М.: Высшая школа, 1983. – 447 с.

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БАГАТОВЕКТОРНІ ДИФЕРЕНЦІАЛЬНІ ПЕРЕТВОРЮВАЧІ ВІБРАЦІЇ ІНФОРМАЦІЙНОЇ ВИМІРЮВАЛЬНОЇ СИСТЕМИ

У статті запропоновано попарне включення первинних перетворювачів для забезпечення дослідження багатовекторних вібрацій. Диференціальна характеристика дозволяє підвищити лінійність характеристики перетворювача в широкому діапазоні вимірів. Спеціальне технічне рішення дозволяє отримати практично однакову чутливість у різних напрямах дії одночасно. Такі датчики доцільно використати при системному стеженні за вібрацією об'єкту, що дозволяє виявляти приховані вібрації, своєчасно виявляти несправності, прогнозувати своєчасний ремонт. У роботі показані результати математичного моделювання і результати теоретичних досліджень.

***Ключові слова*:** *вимірювальний перетворювач, інформаційна система, багатовекторний датчик, тензоперетворювач*

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МНОГОВЕКТОРНЫЕ ДИФФЕРЕНЦИАЛЬНЫЕ ПРЕОБРАЗОВАТЕЛИ ВИБРАЦИИ ИНФОРМАЦИОННОЙ ИЗМЕРИТЕЛЬНОЙ СИСТЕМЫ

В статье предложено попарное включение первичных преобразователей для обеспечения исследования многовекторных вибраций. Дифференциальная характеристика позволяет повысить линейность характеристики преобразователя в широком диапазоне измерений. Специальное техническое решение позволяет получить практически одинаковую чувствительность в разных направлениях действия одновременно. Такие датчики целесообразно использовать при системном слежении за вибрацией объекта, что позволяет выявлять скрытые вибрации, своевременно выявлять неисправности, прогнозировать своевременный ремонт. В работе показаны результаты математического моделирования и результаты теоретических исследований.

Ключевые слова: *измерительный преобразователь, информационная система, многовекторный датчик, тензопреобразователь.*