Investigation and diagnosis are considered for the states of machines and mechanisms. A phase chronometric method is proposed for data-acquisition tracking for machine and mechanism life cycles.

Key words: phase chronometry, time intervals, measurement data, diagnosis, life cycle.

Designing is complicated and ambiguous, being essentially related to scientific research, and to search for and analysis of alternative solutions. There are spreads in the characteristics for the mechanical properties of materials and the carrying capacities of constructions, which are objective features of the materials and consequently of the machine components. This means that a final solution cannot be obtained if there is an inadequate scientific level in methods of calculation and low accuracies in the values for the physical characteristics of materials (elastic modulus, shear modulus, hardness, and so on), and also low accuracy for the parameters of physical processes (coefficient of friction, vibrational velocity, pressure, and so on). For this reason, the selection and testing of new designs requires considerable efforts, with the formulation of experiments and an inevitably large volume of various tests. At present, design tasks are handled by tests on various lines [1]:

1) choice of a rational design, choice of friction pairs, comprehensive examination of the strength and wear resistance, and refinement of the shapes for interacting surfaces;

2) comparative tests for reliability and working life on subsystems, units, and so on under conditions approximating to the working ones;

3) comprehensive test-bed studies on experimental specimens and the first routinely produced ones for machines in order to confirm the basic working characteristics and the parameters of the working cycle, with refinement of the regulation methods, assembly quality, and the limiting modes of operation allowed by the conditions for reliability and failure-free operation;

4) field and full-scale working tests to examine the effects of working loads and conditions, with the choice of diagnosis methods, emergency protection, and periodicity of technical servicing;

5) testing machines on test beds and under plant conditions for devising algorithms for checking the correctness of functioning, the accuracy, the adjustment, the regulation, and the calibration of means of measurement and control systems;

6) accelerated comprehensive diagnostic tests in order to reduce costs, with the development of methods of regulation and the identification of defects. These occupy a special place and require a scientific approach and laborious preparations, including modifications to components, since in accelerated modes it is difficult to provide equivalents to working conditions; and

7) revision of repair periodicity, and of the times and volumes of such work, together with methods of checking repair quality.

A major object of tests is to define an algorithm for evaluating the object state (formulating diagnostic features, classification of them, and forecasting). Various methods and instruments are used to determine individual sets of parameters and to devise a variety of approaches to estimating the current system state. A diagnostic system with its own methods should be
set up for a particular type of component, with a range of physical quantities and metrological characteristics. For example, experts on automobile testing say that “tests provide data for improving the operation at each stage in the life cycle, but they do not provide an acceptable theory for optimal construction of the organization, the planning, the processing, the analysis, and the storage of results, in spite of the fact that the costs of personal, time, and material resources for them may attain 70% of the total costs for setting up new automobile models” [2]. That situation is characteristic also of general engineering.

Tests accompany all stages in the life cycle, but the unsatisfactory position as regards developing designs is associated with inadequate scientific knowledge and metrological level in traditional methods and means of diagnosis. Consequently, the tests have an unacceptably large volume and are lengthy, and they require considerable expenditure to handle the tasks. It is regularly found that unresolved problems remain, and designs are modified at the working stage.

There have been sharp contractions in the volumes of new production in all branches of engineering, which inevitably have to work with worn-out transportation and equipment for various purposes, which have reached the end of their established working lives. The following need to be provided under these conditions for safe rational and economically sound operation:

- diagnosis of the current stage of a standard object;
- forecast monitoring of safe operation;
- transfer from a system of planned preventive repairs to a system of repairs in accordance with the current technical state;
- scientifically sound evaluation of residual working life; and
- reliable emergency protection.

Up till now, these problems have not been resolved for complicated engineering systems (turbines, hydraulic systems, gas-turbine engines, and so on), which confirms the practices established in setting up and operating engineering products. Primarily, this occurs because the metrological support for most branches of engineering in fact is at an average level of accuracy (error 0.001–1%), and consequently traditional approaches to examination and diagnosis of functioning systems have low informativeness [3, 4].

Current conditions require methods and data-acquisition systems that provide prompt recording for degradation and for observing initiating defects. There remains an unresolved problem of data exchange between stages in the life cycle, particularly during use, where information is minimized to reduce the costs, particularly in development and production. Efficient links can be provided between life-cycle stages if the data-basis and metrological accompaniment are constructed on unified scientific principles.

There are widely used amplitude methods and means of diagnosis and emergency protection, but their low accuracy and insufficient response rate give no guarantee of preventing emergencies and catastrophes. Each method must be evaluated for its possibilities and limitations.

The performance of a diagnostic method is determined by the following:

1) the physical effect used;
2) the relationship between the measured physical quantities and the working-cycle parameters for a mechanism or component parts of the design;
3) the scope for identifying individual characteristics in order to evaluate the current state of a routine-production item;
4) the sensitivity of the monitored parameters to deviations in the working cycle from nominal values and changes in the interactions between device elements; and
5) the methods and means of measurement for recording fast processes to provide reliable emergency protection.

These factors are responsible for a range of tasks, and also are related to the reliability and depth of the diagnosis. The scope for widely used methods of evaluating object state is determined by the physical effects employed (vibroacoustic measurements, thermal measurements, electrodynamic recordings, and so on), which may occur during operation, while the working cycle itself is monitored for correspondence with established parameters (parametric diagnosis). At present, one employs mainly amplitude methods, amongst which vibrational diagnosis occupies the leading position.

The cause of vibrations lies in oscillatory processes arising by interaction between components [4]. Machines and mechanisms have characteristic vibrations arising from manufacturing errors, whose level as a rule substantially exceeds the