# On Increasing Informativity and Reliability of the Results of Condition Diagnostics of Materials and Goods

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**Abstract.** The article proposes the results of the development of new high-precision measuring means for solving applied measuring problems when diagnosing the state of structural materials and products in operation. New contactless optical measuring means based on modern laser technologies and new methods of optical interferometry are described. The original software for preparation, measurement and processing of the obtained measurement results is proposed. The developed promising optical measuring complex is described, the use of which for solving measuring problems during diagnostics of the state of structural materials and products makes it possible to increase the information content and reliability of measurement results up to 30%, as well as improve the quality of measurement results up to 40%.

**Keywords:** Construction materials · Condition diagnostics · Optical measuring means · Displacement measurement · Software · Simulation of diagnostic processes

## 1 Introduction

Ensuring safe operation and preventing emergencies during the operation of products for various purposes is possible through periodic diagnostics of the state of structural materials and the marked products themselves. This makes it possible to systematically monitor the state of structural materials and products in operation, timely assess the residual resource of their operation and promptly make decisions either about the possibility of further operation or about its termination.

In connection with the above, it becomes relevant to increase the information content and reliability of the results of diagnostics of the state of structural materials and products in operation.

The development of new contactless optical measuring means based on modern laser technologies and new methods of optical interferometry is one of the most relevant and promising areas for achieving an increase in the information content and reliability of the results of diagnostics of the state.


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The use of such measuring means can significantly increase the information content, reliability and quality of measurement results, and, respectively, the results of diagnostics of the state of structural materials and goods in operation.

## 2 Optical Measuring Complex and Its Description

To solve this problem, a new optical measuring set-up has been proposed. Its structure is shown schematically in Fig. 1.

The components of the set-up are a control system (1), a new measuring mean (2), a device for protecting a measuring mean from the influence of internal destabilizing influences and correction of measurement results (3), a device for protecting a measuring mean from the influence of external destabilizing influences and correction of measurement results (4), a system for *a priori* analysis and preparation for measurements (5), registration of measurement results (6) and a system for processing and *a posteriori* analysis of measurement results (7).

The control system (1) provides control and preparation for measurements, registration and correction of measurement results during their performance and processing of the obtained measurement results after their completion.

Measuring mean (2) (optical interference device for contactless measurement of small spatial displacements of control surfaces) provides contactless measurements of the small spatial displacements of control object surfaces.

The proposed measuring mean (2) is based on the design of a laser two-way interferometer with aligned branches.

The measuring mean (2) can be implemented in design options for measuring small linear displacement, small linear and angular displacements, small linear and all angular (spatial) displacements of the control object surface.

Each of the design options can be used both as part of stationary and as part of mobile diagnostic station using active acoustic methods for monitoring and diagnosing the state of materials in instrument making, mechanical engineering, shipbuilding, aircraft construction, the fuel and energy complex, etc.

All possible design options for measuring mean (2), as well as devices for protection (3) and (4) are scientifically grounded, tested, passed trial operation, and protected by patents of the Russian Federation for inventions [1–6].

The system of *a priori* analysis and preparation for measurements (5) makes it possible to carry out preliminary predictive modeling of the dependences of changes in small displacements of the surfaces of test objects for the used active acoustic method of non-destructive testing and distributions of the intensity of optical fields of interference patterns during measurements.

The system for recording measurement results (6) makes it possible to register the intensity of the optical field of the interference pattern in specified areas during measurements.

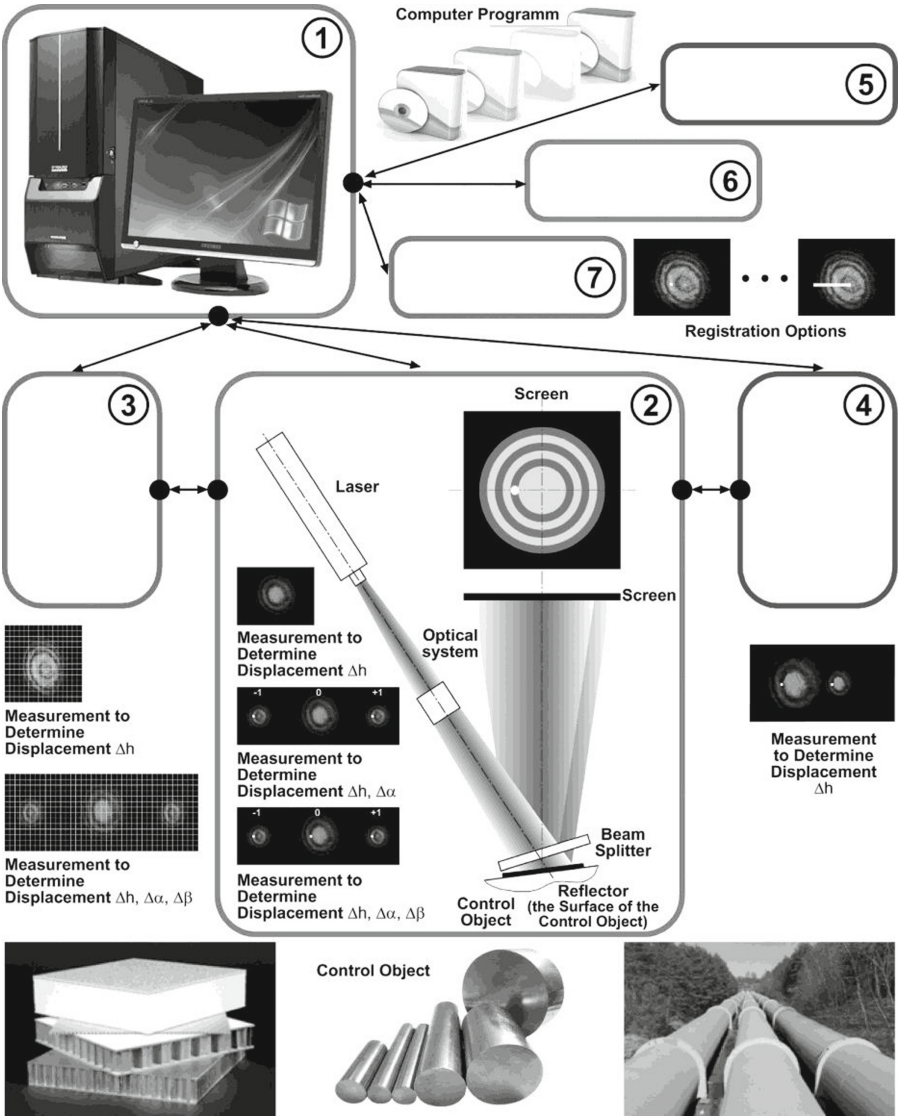


**Fig. 1.** Scheme of optical measuring complex

The system for processing and *a posteriori* analysis of measurement results (7) allows processing the measurement results after their completion and recognition of the obtained measurement results using the results of preliminary predictive modeling the dependences of changes in small displacements of the control object surfaces for the used active acoustic method of non-destructive testing, obtained during *a priori* analysis.

To ensure the functioning of the proposed set-up, original software has been developed, which is included in systems (5)–(7).

The pointed software contains:

(i) computer programs for modeling the intensity distributions of optical fields of interference patterns for preliminary predictive modeling of the measurement process, which take into account the geometric characteristics of the measuring circuit, the type of polarization and the type of beam splitter;
(ii) computer programs for modeling the dependencies of changes in small displacements of the control object surfaces for the used active acoustic method of non-destructive testing for preliminary predictive modeling of the state of the control object, which allow taking into account the spatial temporal distribution of sources of probing influence, the material type of the control object, its physical and mechanical characteristics, types of elastic waves propagating in a given material and the features of the arising wave processes;
(iii) computer programs for recording and processing the intensity of optical fields from specified areas of the interference pattern;
(iv) computer program for determining the total intensity of the optical field of the interference pattern and correcting the measurement results of the intensity during measurements;
(v) computer program for correcting measurement results from the influence of external destabilizing influences.

All above-mentioned computer programs are promised contactless means designed to measurements of optical displacements [7] and protected by certificates of the Russian Federation on state registration of computer programs [8–18].

## 3 Conclusion

Summarizing the results described above, we can draw the following conclusions:

1. New high-precision optical measuring means have been developed for solving applied measuring problems when diagnosing the state of structural materials and goods in operation, which are functionally combined into an optical measuring set-up.
2. The proposed new technical solutions and original software included in the set-up are scientifically grounded, tested, and also protected by patents of the Russian Federation for inventions and certificates of the Russian Federation on state registration of computer programs, respectively.
3. The use of the proposed complex for solving measuring problems during diagnostics of the state of materials and products allows increasing the information content and reliability of measurement results up to 30%, as well as improving the quality of measurement results up to 40%.

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