

# Problems of systems dataware using optoelectronic measuring means of linear displacement

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**Abstract.** Problems of the dataware of the systems with the use of optoelectronic means of the linear displacement are considered in the article. The classification of the known physical effects, realized by the means of information-measuring systems, is given. The organized analysis of information flows in technical systems from the standpoint of determination of inaccuracies of measurement and management was conducted. In spite of achieved successes in automation of machine-building and instruments-building equipment in the field of dataware of the technical systems, there are unresolved problems, concerning the qualitative aspect of the production process. It was shown that the given problem can be solved using optoelectronic laser information-measuring systems. Such information-measuring systems are capable of not only executing the measuring functions, but also solving the problems of management and control during processing, thereby guaranteeing the quality of final products.

## 1. Introduction

The current stage of development of information-measuring systems is inextricably linked with the problems of providing high quality of products, with requirements of continuous improvement of the accuracy and performance of plants and equipment. Successful solution of problems is impossible without the use of automation equipment at the proper level of information security.

High demands on the characteristics of machines and equipment determine the priority development of closed production systems, where a crucial role is played by the automatic control system with multiloop feedback. One of the main elements along the contour of the multiloop feedback is the information-measuring system, which performs the measurement and processing of primary information through mechanical and thermal quantities (displacement, density, pressure, temperature etc.). Measurement and processing of the primary information produced during the execution of the measurement process and the formation of information flows, the significance of which is reflected in the indicators of the accuracy of workpiece, improve processing performance and dynamic characteristics of the processes of control and regulation.

## 2. Materials and methods

The feature of dataware is not only achievement of high informativeness of automation means in a wide range of values of identifiable parameters, but also provision of sufficient reliability of operation of the information system itself under the conditions of influence of destabilizing factors of the working environment, which imposes its own specifics on the solution of metrological tasks in the field.



Modern development of production automation is moving towards the creation of information systems of different levels and purposes in automatic control systems: computing, information-measuring systems (IMS), information-diagnostic, with the status of the subsystem.

The capabilities of existing and development of promising technologies are implemented with the use of computer technology and automatic measuring devices: devices of active control of physical parameters, measurement transducers of displacements by the movement types of executive devices, and other measuring devices necessary to obtain qualitative and quantitative information when organizing the measurement process. This information can be transmitted to the automatic control system through wired or wireless (optical, acoustic, electromagnetic) communication channels in the appropriate coded format, forming information flows, the role of which increases with growth of level of automation equipment due to the wider application of the measuring and computing resources: computers and processors, numerical control systems, programmable controllers, etc. [2, 7].

To organize this process and its management requires certain information that may be classified to original or original and current. Background information is pre-determined and prescribed by the algorithm of the measurement process. It contains the information necessary to perform operations with the required output parameters within specified tolerances for accuracy and performance.

### **3. The study of the problem of information support systems using optoelectronic means of measuring linear displacement**

Current information is generated during execution of the measurement process in strictly defined points in time with different physical nature measuring instruments – measuring instruments (MI). These are the data concerning the actual position and velocity (acceleration) of the executive bodies and other equipment, recorded and controlled parameters of the measurement process that can be characterized as values that are necessary for solving management tasks. The accuracy and timeliness of this information, obtained by the direct or indirect method, are largely determined by the type of MI, the methods of encoding and processing the primary measuring information and by the working environment. This type of information may include diagnostic data of the character formed by the different sensor (signal) devices equipment when it reaches the limit of the operation mode parameters of the measurement process.

Measurement technique using the system of measuring instruments with different level of measurement automation is designed to objectively assess the quality of the products, contribute to the achievement of the required accuracy and efficiency of the process [3, 9]. It provides the following automation tools:

- use of new production processes;
- apply advanced technical, software, computer equipment and metrological provision of measuring instruments;
- create perspective views of measuring instruments and on their basis to realize effective automatic control system;
- carry out automated monitoring of parameters in real time with the subsequent processing of measurement data with high reliability, minimum cost, etc.

With the growth of quantitative and qualitative indicators of means of equipment automation, the quality of the production process increases, and, hence, consumer properties of products, having great social and economic importance, do.

However, the production system, like any other technical or biological one, is exposed to various influences of environment, which, through internal and/or external impact (mechanical, thermal, chemical, electrical, magnetic, acoustic, etc.), affect its subsystems with different intensity and impair the processes of their functioning, causing the corresponding errors. A part of the processes is reversible and manageable [4, 10], since the parameters of the main and auxiliary devices are changed temporarily in a certain range without a trend of progressive deterioration, and the other part is irreversible and leads to a gradual and increasing deterioration in system parameters over time. The resulting errors influence, in general, the value of geometric and kinematic accuracy of the

dimensional equipment chain, reducing the quality of the production process.

In the course of the production system functioning, the errors, caused by imperfection of measuring means of IMS, methods of measuring transformations of the parameters of the production process and data processing, infringements of operation modes and impacts of environment factors, are no less important.

Understanding the modern manufacturing process [5, 6] as a multidimensional and multivariate object of management and control with probabilistic character of changes of the output parameters with constant input variables under conditions of influencing values, allows one to consider the process of automation equipment in terms of its components. They are the functions of control and management, on the effectiveness of the technical implementation of which, in a varying degree, the basic problems of automation depend. These problems concern enhancement of the accuracy, productivity and equipment reliability at all levels of the automated control system.

Automation of the production process is possible provided that there is stability and determinatness of the system. Therefore, the task of monitoring the measured and controlled parameters of the production process through technical means of IMS consists in the measurement transformation using the corresponding values, determined by type of technical measurements: mechanical (displacements, linear dimensions, vibration, density, viscosity, level, flow, tilt, etc.) and thermotechnic (temperature, pressure, etc.). The control problem consists in compensation of the arising errors and deviations in the process of treatment or control through the management system. The latter contains the control device, the actuator, the executive device of forming movements or spatial manipulation. To improve the accuracy and flexibility of control, processor means are included into the drive structure of technological equipment, thus granting it the function of a universal regulator. In this case, the diagram of the system is closed with contour adaptation and direct control of the input parameters.

In systems with direct control of input parameters, the influence of production factors on the accuracy of the withstood parameter is completely excluded, and therefore, they are the most advanced systems at present [7, 8]. Realising control of parameters of destabilizing nature in the course of the production process (temperature, vibration, etc.) allows the system to track the random disturbance and to adapt (adjustment of system parameters). Systems, controlling output parameters, allow one to register the deviation of parameters from the those, set by control program (flow, pressure, rotational speed, etc.). The repeatability of errors, as the conducted research [1] shows, is reduced with the increase of the automation degree of the equipment, and therefore, the quality of the products, manufactured using this equipment, increases.

Despite the advances in automation of machine-building and instrument-making equipment, in the field of information management for technical systems, there are unresolved issues affecting the qualitative aspect of the production process. The solution of such problems is possible using advanced IMS that will allow one to more fully meet the growing requirements of production. So, there is no requirement for accuracy of positioning the connecting link  $10^{-5} \dots 10^{-7}$  and higher, and for the range of movements by the conversion factor of not less than 1000...10000:1 or more for angular and linear values.

The problems of measuring the linear (angular) displacements and velocities (accelerations) of the executive bodies of technological equipment with the measurement range of the displacement  $L > (2 \dots 10) \text{ m}$ , and high speed  $V > 1.0 \text{ m/s}$ , as well as those in the field of low velocities  $V < 0.01 \text{ m/s}$ , are not completely solved. These issues were identified as particularly acute ones when creating medium- and large-sized modules, industrial robots, automated warehouses and improving their productivity. In the structure of these systems there is a wide range of measurement tools that implement different methods of measurement of parameters of the production process, which can be explained by lack of optimal, from the standpoint of cost, accuracy, speed, and functionality of technical means.

The issues of integration of measuring devices of IMS with mechanical elements and assemblies of equipment are not fully resolved, processor means for processing the primary information are insufficiently and inefficiently used. A limiting factor in the use of measuring means of IMS of automated equipment is achievable performance – the threshold of sensitivity, accuracy, response

speed, cost.

As of today, resolution enhancement using traditional methods appears to be hopeless; there is a necessity of search of principally new solutions of information support of technical systems and methods for measuring means construction. The required threshold is able to provide the information-measuring system with measuring devices, based on the wave principles of conversion, with a small wavelength of carrying ascillations – ultrasonic, photoelectric and optical, which have found application in precision equipment and have well-known advantages and disadvantages.

This problem can be solved by using optoelectronic laser IMS. The appearance of the first optoelectronic IMS is conditioned by the desire for automation of optical measurements. Great opportunities have been opened to optoelectronic IMS after the development of lasers. Such laser merit as high spatial and temporal coherence is of primary importance. Spatial and temporal parameters of laser radiation are defined both by the phase state of the active medium (solid, liquid, gaseous) and by different structures of resonators and the mode of pumping.

With high resolution (0.01  $\mu\text{m}$ ), laser IMS have small periodic and occasional technical mistakes that are typical of conventional measuring means (errors of such types as inconsistencies of scale bars, beats of measuring screws, the changes of the scale due to heat and pollutants, etc.).

#### 4. Conclusion

The contactless principle of the interference measurement, modularity of constructions, a possibility of constructing multi-axis IMS, the presence of connection with the computer – all this allows modern laser IMS to fit organically in complex technical systems, for example, in IMS of multi-axis machine tools and measuring machines; to carry out not only measurement functions, but also to solve the tasks of management and monitoring during treatment, thus ensuring the quality of finished products.

IMS, based on laser interferometers can compete with traditional measuring tools, if the measurements are conducted in the ranges with an upper limit of measurement up to 1 m. If the upper limit of the measurement range exceeds 1 m, the IMS on the basis of optoelectronic laser interferometers performance by metrological and economic criteria are superior to traditional measuring systems. This conclusion is confirmed by the practice of the industrial production of metal-cutting machine tools and measuring machines, equipped on the basis of laser IMS. Currently, there are more than a dozen machines of this type, including precision machine tools for diamond machining; turning, milling, grinding machines; measuring machines for controlling lead screw, bar scales, gear wheels etc.

Thus, the practical use of laser IMS by domestic and foreign firms shows that by the metrological indicators, they are superior to traditional IMS.

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