GAUGING INFORMATION SYSTEMS, MEANS OF TECHNOLOGICAL DIAGNOSTICS AND INTELLIGENT GAUGES IN NUCLEAR POWER ENGINEERING AND INDUSTRY. Current state and perspective views.

Nikolay R. KUZELEV
Research Institute of Technical Physics and Automation (VNIITFA), Moscow, Russia
Tel: +7(499) 6112522, Fax: +7(499) 6115434

Abstract

Measuring information systems, process diagnostic facilities and smart sensors (automated nondestructive testing systems - ANDTS) perform measuring, monitoring and control functions. They ensure safety use of NPP, nuclear power and industrial operations, and are extensively used in the defense industry, scientific research, medical care, agriculture and ecology.

ANDTS are used for:

- NDT and diagnostics of units and devices
- material/facility component makeup control
- process automation.

Use is made of hardware methods of measured parameter recording, automated control data decoding, documenting and long-term storage, including those for especially hazardous production control.

ANDTS enable real-time bundled software-assisted detection and identification of a bomb or a pre-emergency facility status.

Portable analyzers help identify especially hazardous materials and determine the content of heavy and toxic elements in aqueous media and atmosphere.

In the process of establishment the nuclear industry has developed a new sustainable line of business – nuclear instrumentation and measuring information technologies. They went through a number of stages and used a wide variety of the current achievements in instrument circuitry and design, development of detectors, recording hardware and methods and ramified control systems.

Advanced measuring information systems are based on sensors that provide incoming initial information. Such sensors, too, have been through several development stages. The initial stage involves use of gages primarily to obtain data on physical quantity values that did not represent measurement information until processed by man. Sensor evolution led to creation of information collecting tools equipped with their own computers and based on state-of-the-art technologies (including Internet technologies) for data processing and transfer to top-level systems. Such sensors which in some cases handle process control tasks alongside information tasks are known as smart sensors.

The specific character of the nuclear industry demanded a wide use of nondestructive testing and process diagnostics (NDT and PD) and some special features of sensors: provision of rational isolation from operating personnel, high resistance to destabilizing factors, and consistency with the process control system. All this required application of a system approach, high degree of automation, computer facilities and robotics, highway-module design method etc. in designing the sensors.

A choice of an NDT method and instrument for the purposes of fault detection and technical diagnostics depends on the parameters of a tested object and inspection conditions.

Key words: measuring information systems, process diagnostic facilities, smart sensors, automated nondestructive testing systems – ANDTS, monitoring, safety, NPP

1. Classification of NDT and PD Methods

Each type of NDT and PD uses methods classified by the following features:

- nature of interaction of physical fields or substances with a tested object
- primary informative parameters
- methods for obtaining primary information.

By their design, testing facilities may be classified as follows:

- self-contained instruments for testing one or more interrelated quality characteristics
- integrated systems, automated lines and checking robots designed to measure a number of basic parameters characterizing the quality of an object
- NDT systems for automated process control by qualitative features.

In terms of tested parameter types, NDT and PD facilities are grouped as follows:

- non-destructive test units (instruments or sets) designed for detection of discontinuance defects (cracks, cavities, lamination etc.)
- geometrics testers (inner and outer diameters, wall/coating/layer thickness, degree of wear etc.)
- physical mechanical/physicochemical parameter tester (electric, magnetic and structural parameters; deviations from a preset composition, hardness, ductility etc.)
- technical diagnostic facilities for defect predictions (discontinuance, change in dimensions and physical mechanical properties, etc.).

NDT and PD methods have been applied in all the industries of the national economy to control quality of parts and structures of various dimensions and materials.

2. Measuring Information Systems for NDT and PD

As nuclear technologies were developed and automated, a new class of measuring information equipment was designed to collect, process, transfer, store and display information as well as generate control actions on a tested object. The basic components of measuring information systems are shown in Fig.1.

Fig.1. Basic Components of Measuring Information Systems

It is through automated control (automate data collection, transfer, processing and accumulation) and control action generation that complex processes may be implemented and high product quality assured.

One way to tackle this task is apply a module design principle by design arrangement using a set of unified modules that must be compatible in terms of design, information, power, software, metrology and operation.

Such an approach helps:

- reduce a nonstandard module range and the number of purchased component suppliers; optimize own production costs and organize production cooperation
- reduce equipment cost and enhance its reliability and operating efficiency through interchangeability of individual modules at the operation stage; reduce SPTA range.

3. Sensor-Monitored Process Parameters

A list of monitored parameters includes the composition and concentration of chemical elements, bulk material moisture content, liquid and bulk substance levels, defects, density, liquid media turbidity, geometry, appearance, thickness of coatings and sheet materials etc. (Fig.2).

Fig. 2. Sensor-Monitored Parameters

Despite the considerable differences in monitoring procedures, the following general requirements are imposed on monitoring facilities:

- most of monitoring facilities must be directly connected to the process equipment (built into process)
- capacity and power availability of various monitoring facilities must be consistent; issues of metrology and reliability of monitoring data representation must be handled.

  Thus monitoring equipment acquires the features of complex automated systems incorporating devices that present and identify a monitored object, check if a measured value is within the tolerance range, equipment technical/metrological serviceability monitoring, monitoring data representation etc.

By their design, monitoring facilities may be classified as follows:

- self-contained devices for monitoring one or several interrelated qualitative characteristics
- integrated systems, automated lines and checking robots designed to measure a number of basic parameters characterizing the quality of an object
- NDT systems for automated process control by qualitative features.

Given below are the current smart sensor trends:

- increasing number of preprocessing functions for signals read off the sensing device
- predominant functions implemented by numerical techniques in built-in microprocessors and microcontrollers
- reduced interference sensitivity and inherent noise levels at the signal preprocessing stage
- enhanced accuracy of sensors through computer-based implementation therein of temperature/time error compensation algorithms
- recording and storage of information about a measured variable exceeding the preset limits
- arrangement of protocol data exchange with system components via the network channel
- implementation of sensor hardware self-monitoring, increased unauthorized access protection of measurement data.

4. Requirements for Creation of Specialized APCS Facilities and Subsystems

The experience gained in the course of creation of NDT and PD, element composition analysis for material and sensors for process automation in the power engineering and industry allows a unified approach to be adopted which implies:

- information compatibility providing for common interface links
- metrological compatibility involving remote metrological serviceability test for equipment, sending signals to a local measuring system in case of instrument failure; operational compatibility allowing for work environment; design compatibility determining an approach to selection of basic design solutions; and power compatibility
- reliability compatibility determining the failure-free operation and maintainability requirements as well as special measures, such as redundancy, serviceability sort testing with automatic shutdown at fault detection etc.

Such an approach to sensor design allows the recent improvement solutions to be implemented even today.

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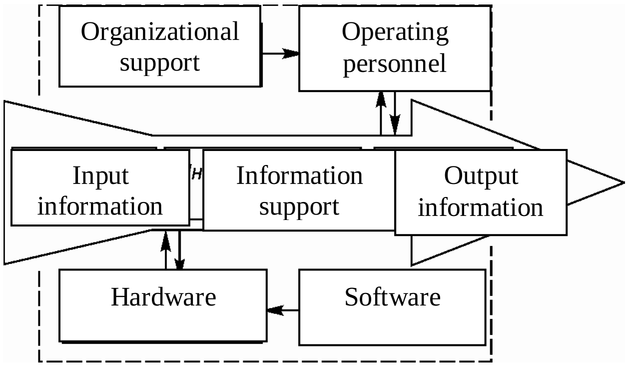

Fig.1. Basic Components of Measuring Information Systems

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Датчики технол. параметров	Process parameter sensors
Радиационные методы	Radiation method
Другие методы	Other methods
Томография	Tomography
Уровень	Level
Химический состав	Chemical composition
Плотность	Density
Влажность	Moisture content
Концентрация	Concentration
Загрязненность	Pollution density
Наличие дефектов	Defects
Толщина покрытий	Coating thickness
Интроскопия	Introscopy
Мутность	Turbidity
Геометрические размеры	Geometry
Текучесть	Ductility
Внешний вид	Appearance

Fig. 2. Sensor-Monitored Parameters