Prospects for the application of intelligent automation in the pulp and paper industry

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Abstract. The issues of using intelligent automation tools in the pulp and paper industry are considered. It is shown that the level of use of intelligent automation tools still remains insignificant. Promising directions for the implementation of intelligent automation tools in pulp and paper production have been identified. Areas where it is possible to obtain the most significant technical and economic effects from the introduction of intelligent automation tools have been identified. The main types of technical automation equipment that can be used to equip automated control systems in process control systems of the pulp and paper industry are demonstrated.

1 Introduction

In the modern world, changes occur extremely quickly and the automation sector is not spared the trend of intellectualization of technical automation equipment (TAE): progress does not stand still, striving for a “higher goal.” In most existing manufacturing facilities, one can find intelligent automation tools such as smart valves, sensors and touch panels, which are also present in the pulp and paper industry [1-3].

A pulp and paper mill is saturated with a variety of technical automation equipment and is a complex facility with an increased fire and explosion hazard, for which an important problem is the detection of deviations in the operation of sensors and actuators from the specified parameters, early detection of abnormal, and most importantly, dangerous situations to prevent them. Only maintaining the technological process for complex control objects on the territory of the pulp and paper mill in the operating range (in regulatory and operational areas) makes it possible to safely operate the equipment [4].

Intelligent automation tools can play an important role in achieving this task. To highlight the intelligent ones among other automation tools, we present some basic provisions of the so-called theory of normal intelligent devices - one of the directions in the field of artificial intelligence research [5]:

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1. For a device to be considered intelligent, it must have the activity to solve problems classified as "non-standard" without human help, that is, completely independently.
2. Also, a device related to the category of intelligent devices requires such a property as purposefulness - the ability to have a goal.
3. Any smart device performs various actions. Such an action that contributes to the achievement of the goal of the smart device (see point 2) is called a goal-directed action. The best at a particular moment, i.e. the purposeful action of the device chosen with the available resources of time, memory and knowledge is called the optimal action. The characterization of the "optimality" of an action is subjective, since different devices a priori have different goals, and is relative.
4. To choose the "optimal" action in the presence of many possible choices, you need to:
   - firstly, to be aware (to predict or know from experience) of the possible consequences after taking, and accordingly, carrying out this or that action;
   - secondly, to be able to determine, from the sets of possible consequences resulting from the decision made as a result of the first step, those that will coincide to a greater extent with the goal given to the device.
5. The following two interrelated tasks are the main tasks of any smart device.
   - First main task. The problem of forecasting by smart devices is solved through the use of models and/or simulators.
   - Second main task. The problem of comparing the correspondence between the possible consequences of the decisions made and the purpose of the device. This theory is based on the fact that the distinctive feature of any intelligent being is "intelligent", purposeful behavior. Obviously, such behavior can be implemented by a self-learning device only through preliminary prediction of the consequences of its actions (and selection of the most optimal ones).

In [6], the mandatory and sufficient characteristics of an intelligent information-measuring system were first indicated:

- ability to improve methods for solving typical measurement problems (optimization);
- ability to master solutions to new problems (gaining new knowledge);
- ability to find new solutions (methods).

To summarize, we can conclude that a device called intelligent is assessed by how successfully it is able to extract knowledge from the external world, build models of the external world and predict various options for its development.

2 Prospects for the use of intelligent automation tools in pulp and paper industry

The prospects for using intellectual tools not only in the pulp and paper industry, but also in other industries are extremely extensive, and with the development of "intelligence" they are only increasing. The development of computer technology makes it possible to use neural networks in control systems - one of the newest directions in the implementation of artificial intelligence. Neural networks find their application in pattern recognition systems, signal processing, prediction and diagnostics, in robotics and other complex systems. A control system developed based on neural technologies has several advantages:

- firstly, neural control technology allows you to build models of complex control objects based on the "black box" principle;
- secondly, neural models easily adapt when the parameters of the modeled object change;

- thirdly, they allow you to implement models for multidimensional objects [7].

So-called intelligent automation systems can provide production with many advantages (quality, economic, technological and more). General list of advantages of systems using intelligent technologies [8]:

- increasing labor productivity and response speed of control elements;
- maximizing optimality in matters of resources (their distribution and consumption) in conjunction with the development of solutions to improve reliability;
- increasing the efficiency of resource use in terms of economic benefits;
- increasing the reliability and efficiency of system equipment and the speed of implementation of operational decisions by improving the quality and efficiency of management activities;
- maintaining devices in a state of stability in cases of accidents and after them;
- improving the working conditions of workers responsible for the technological process within the framework of the regulations;
- providing operators with timely and reliable information about the state of the system and its components;
- reducing the number of errors caused by human factors and the damage caused by them;
- improving system condition diagnostics;
- increasing the availability of quick control;
- reduction of diagnostic and repair costs;
- technical accounting and resource control.

3 Technical and economic effect

The introduction of intelligent automation tools in the pulp and paper industry and directly at pulp and paper mills entails a complex economic effect, reflected in its various manifestations:

- In technology. Multiple improvements in the stability of the technological process, the ability to more quickly identify deviations from technological regulations, reduction of static and dynamic errors due to better execution of the control signal.
- In production. The number of accidents can be reduced thanks to the rapid identification of inconsistencies in the state of the system and/or equipment with technological regulations and awareness of all the weak points of the process and possible disturbing influences that may be exerted on it from the outside world.
- In the instrumentation department. Increased production levels due to the introduction of intelligent positioners, improved quality of data on the condition of control valves, actuators and positioners, and the ability to more accurately interpret data using diagnostic programs. Reduced costs for quick calibration and diagnostics with a high degree of reliability of the detected fault.

As an example, let's consider a feasibility study for the use of smart technologies on a paper making machine. The economic effect can be obtained from:

- improving paper grade;
- reducing raw material consumption;
- increasing system reliability;
- reducing defects [8].

 https://doi.org/10.1051/e3sconf/202561303001

4 Intelligent automation tools in pulp and paper industry

4.1 Positioners

With the development of electronic computing technology and digital data transmission technology, digital positioners have received significant development. They provided users with completely new capabilities related to more accurate and reliable digital signal processing, data processing, database creation and the use of controllers in the process of continuous data acquisition and processing.

This, in turn, allowed the creation of new diagnostic tools and significantly improved the performance of positioners, the quality of regulation and increased online diagnostic capabilities.

Nowadays, there is increasingly a transition to intelligent processing of information received and processed by the positioner, the development of software and diagnostic systems to take into account a larger number of parameters, and therefore digital positioners are called intelligent or smart positioners [9].

As an example, consider a digital positioner (intelligent valve controller) Neles ND 9000, the appearance and diagram of which is shown in Figure 1 [10]:

Fig. 1. Appearance of Neles ND9000.

The ND 9000 positioner has a local interface for monitoring the valve position, the set valve position. The local interface allows you to implement two operating modes - AU (AUTO) and RU (NAN). In AC mode, the positioner regulates the valve position in accordance with the 4-20 mA control signal. In RU mode, the valve position can be adjusted manually. Remote control mode uses FieldCare software to diagnose the control valve.

The intelligent positioner ND 9000 has advanced diagnostics, which includes: self-diagnosis; operational diagnostics; diagnostics of operational characteristics; data transmission diagnostics; expanded independent testing capabilities; display of valve performance characteristics in real time.

Using diagnostic software systems, it is possible to monitor the condition of all valves on which the positioner is installed and provide information to the automated control system of the technological process [9].

4.2 Smart valves

With the proliferation of smart valves with digital positioners in the pulp and paper industry, solutions to many problems are becoming possible. If not the primary, then one of the most important tasks solved with the help of smart valves with digital positioners is maintaining the reliability of the valve, as well as accurately predicting its performance over a pre-specified operating life, for example, up to scheduled inspections or repairs.

Proper use of this type of device allows you to achieve a variety of results. One of the consequences is balanced planning of the technical process, equipment maintenance, repairs and transfer of the need for verification to the diagnostic system. An important consequence is also the tracking of the condition of spare parts and their planning, which in turn will reduce the amount of work on revisions by 60%. The diagnostic system can show errors, system failures, sudden appearance of blockages, accumulation of buildup, etc. This will help prevent emergency situations. Diagnostics will show why the failure occurred and can help personnel better calibrate the positioner for specific operating conditions [10-11].

Unlike a traditional control valve, a smart valve uses a digital positioner and associated software to communicate with the controller. The use of intelligent actuators makes it possible to obtain such data or implement such functions that, in the case of using valves with traditional positioners, would require expensive equipment, on-site revision of the valve and positioner, and in some cases, removal of the valve from the pipeline, which is not appropriate for a continuous process flowing at the pulp and paper mill. That is why smart valves have found their niche in the production of pulp and paper products [12].

As an example, consider the YSIQ(D)10J smart valve, the appearance of which is shown in Figure 2.

Fig. 2. Smart valve YSIQ(D)10J.

YSIQ(D)10J series single-seated intelligent control valves are an automated plunger-seat control valve with a body closed in a “heating jacket” for the purpose of stable thermal insulation and preventing crystallization of the flowing medium when the ambient temperature drops: application for process fluids, for which are characterized by high density, increased crystallization and viscosity of the flowing medium [13].

According to its technical characteristics, such an intelligent valve fits well into the technology regulation at many pulp and paper enterprises.

4.3 Smart sensors

Smart sensors are adaptive sensors that contain operating algorithms and parameters that can be changed based on external signals, and which, in addition, implement a metrological self-monitoring function [14].

A distinctive feature of smart sensors is their ability to self-heal and self-learn after a single failure. In English-language literature, sensors of this type are called “smart sensors”. The term stuck in the mid-80s.

Today, a smart sensor is understood as a sensor with built-in electronics, including: ADC, microprocessor, digital signal processor, system on a chip, etc., and a digital interface supporting network protocols for communication. Thus, a smart sensor can be included in a

 https://doi.org/10.1051/e3sconf/202561303001

wireless or wired sensor network, thanks to the self-identification function in the network along with other devices.

The network interface of a smart sensor allows you not only to connect it to the network, but also to set it up, configure it, select an operating mode, and diagnose the sensor. The ability to carry out these operations remotely is an advantage of smart sensors; they are easier to both operate and maintain.

In Figure 3. A block diagram is presented, which shows the main blocks of an intelligent sensor, the minimum required for the sensor to be considered as such. The incoming analog signal (one or more) is amplified and then converted into a digital signal for further processing [15].

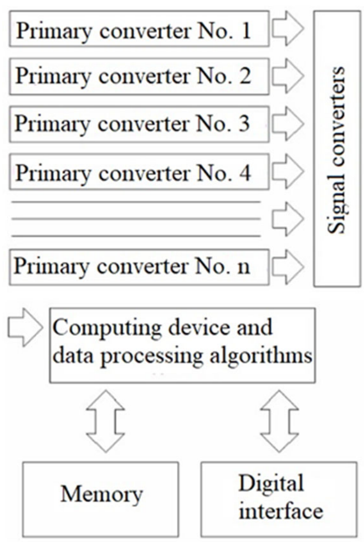

Fig. 3. Block diagram of a smart sensor.

The main area of application of smart sensors is distributed integrated computer systems (DCS) for monitoring and control. To manage complex technical objects (processes) with a dynamically changing state, DCSs are needed that are capable of solving problems at a high pace in real time. Oil refining, chemical and cellulose industries, when using SS, are able to monitor adjustable parameters with high accuracy and quick response, which makes it possible to significantly reduce the number of defects and possible emergency situations [16]. As an example of a smart sensor, consider the EJX110A differential pressure sensor (Figure 4) [17].

Fig. 4. Appearance of EJX110A.

The Yokogawa EJX110A differential pressure sensor is the base model of the DPharpEJX family of high technology sensors and is designed for flow measurement (with the diaphragm measurement method), as well as for level and density measurement using the hydrostatic method.

The EJX110A differential pressure sensor contains a monocrystalline silicon resonant sensing element and can be used to measure liquid, gas or steam flow, as well as measure liquid level, density and pressure. Its 4-20 mA DC output corresponds to the measured differential pressure. The highly accurate and robust sensing element also allows static pressure to be measured, which can be displayed on the built-in indicator display or monitored remotely using digital communication with a BRAIN or HART communicator. Other key features include fast response, remote parameter setting using digital communications, diagnostics and an optional status output for high/low pressure alarms. Multipoint measurement technology provides advanced diagnostics that can detect disturbances such as a blocked impulse line or a broken heating main [18].

DPharp is a series of high precision intelligent pressure transmitters. EJX series pressure transducers (sensors) have all the functions of modern smart sensors. At the same time, in the EJX series the design of the capsule has been significantly changed, due to which the response time has been significantly reduced (now it is 95 ms - EJX - this is one of the fastest responses among other representatives of these sensors). In addition, the electronics have been redesigned (now they are fully redundant even for standard basic versions), functions have been added, and accuracy has been improved [19].

5 Conclusion

Summarizing all of the above, we can say with confidence that the use of intelligent automation tools in the pulp and paper industry is effective, since the quality of the products improves; the flow of the technological process is stabilized both as a whole and in its individual components; equipment condition is effectively monitored; all errors and malfunctions that arise during the production process are promptly detected; the possibility of forecasting appears; economic costs are reduced; working conditions for staff are improved; the influence of the “human factor” on the process is reduced to an acceptable minimum; it becomes possible to cover the entire production process and implement everything in a single digital SCADA system.

This paper has been supported by the Kazan Federal University Strategic Academic Leadership Program ("PRIORITY-2030").

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