IMPLEMENTATION OF VIRTUAL ANALYZERS IN THE CONTROL OF INDUSTRIAL TECHNOLOGICAL PROCESSES

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Introduction In most practical cases, real-time control of technological processes is carried out based on the results of production monitoring. Monitoring, in turn, is implemented through the collection and preliminary processing of data obtained from measuring instruments and complexes, which are typically integrated into Automated Process Control Systems (APCS), as well as from laboratory analyses of intermediate and final products.

Unfortunately, the results obtained from plant laboratory analyses usually lack the required completeness and timeliness. Practical experience shows that, in some cases, even their reliability is insufficient. The main reason for this lies in the mismatch between the throughput capacity and technological capabilities of laboratory analytical equipment and the actual needs of modern production systems.

The use of on-line analyzers significantly improves the timeliness of monitoring material flows. However, such devices are often very expensive, require regular maintenance by highly qualified personnel, and still fail to provide sufficient informational completeness for the implementation of automated optimal control loops of technological processes.

Hence, a scientific and technical problem arises — to improve the completeness, responsiveness, and reliability of information support for technological personnel by developing and implementing a Virtual Monitoring System (VMS) for technological processes.

The Role of Virtual Analyzers in Automated Process Control Systems

At modern industrial facilities, two main types of instruments are commonly used for measuring process parameters: on-line (flow) analyzers and laboratory analytical tools.

Flow analyzers are designed to determine the physicochemical properties of process streams in real time, while laboratory analyses provide highly accurate results but are performed periodically, which prevents timely response to changes in process conditions.

Despite the high precision and continuity of measurements, self-diagnostics, and visualization capabilities, on-line analyzers also have several drawbacks. They require regular calibration, skilled maintenance, and—most importantly—are associated with high equipment and operational costs.

The use of virtual analyzers (VAs) at industrial enterprises complements the traditional monitoring methods described above. A virtual analyzer represents a computational model intended for the indirect estimation of key quality indicators of a technological process.
Such models are developed using historical production data together with results of laboratory analyses performed in accordance with GOST or ASTM standards.

The selection of regressors (input variables) for the model is determined by process engineers, relying on their professional knowledge and experience accumulated during the operation of specific technological units or process chains.

Thus, virtual analyzers enable operators to monitor process performance even in cases where flow analyzers fail or laboratory results are delayed—particularly in the absence of a Laboratory Information Management System (LIMS).

A virtual analyzer can either be integrated into an Automated Process Control System (APCS)—for instance, as part of a Decision Support System (DSS)—or operate independently as an intelligent supervisory layer over the existing control loop.
In practice, it can be implemented on any networked computer with access to process monitoring data, on-line analyzer readings, and laboratory analysis results of material flows.

When using intelligent virtual analyzers (IVAs), an additional source of information is provided by the knowledge base (KB).
The corresponding knowledge base may be implemented either as a traditional relational database (RDB) or as a data warehouse, which enables the accumulation of technological experience in a multidimensional data format.

The interaction scheme of the virtual analyzer with the Automated Process Control System (APCS) is shown in Figure 1.

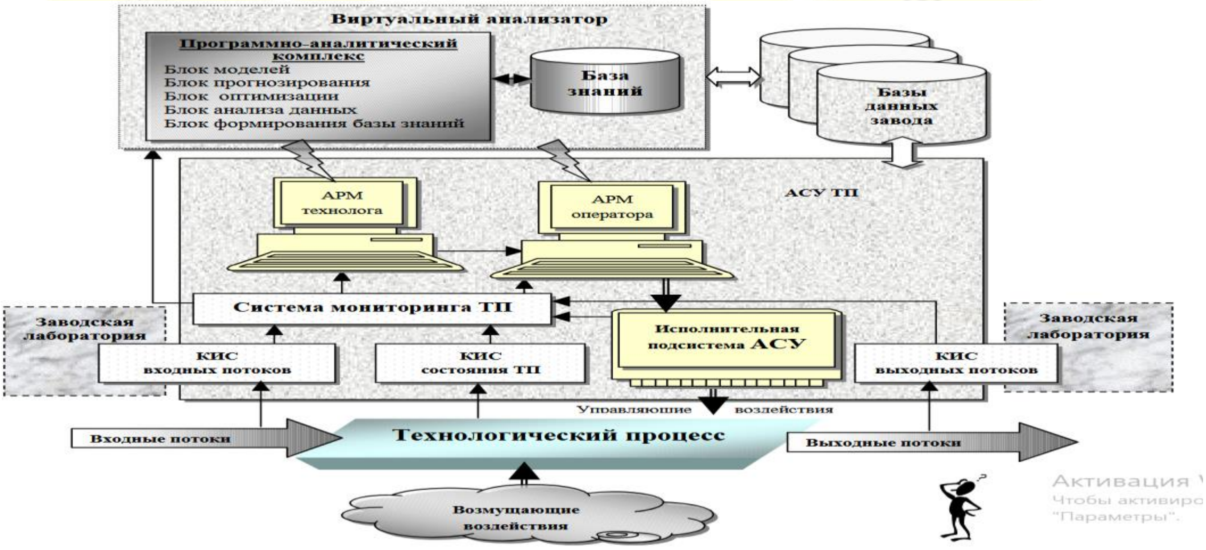

Figure 1. Interaction of the virtual analyzer with the Automated Process Control System (APCS)

The main sources of information for virtual analysis include:

- Hidden redundancy contained in the physicochemical measurements obtained from existing Industrial Information Systems (IIS) and from plant laboratory analyses;
- Retrospective technological knowledge accumulated during process control operations and stored in the local production database.

Virtual analyzers can be used to address the following tasks:

- Prediction of product quality for a selected technological regime;
- Estimation of input material flow parameters and adjustment of their specification requirements;
- Formation of optimal control actions (decisions) according to predefined quality criteria;
- Identification and correct consideration of significant interdependencies among process parameters;
- Search for the most rational control strategies under various efficiency criteria;
- Exploration of new technological operating modes for different performance indicators;
- Analysis of the significance and influence functions of individual technological parameters;
- Assessment of industrial and environmental safety during plant operation;
- Detection of hidden technological and technical threats and timely notification of potential risks;
- Ensuring stable and safe operation of industrial units, serving as a platform for the development of a preventive industrial safety system;
- Verification of measuring and control instrumentation;
- Foundation for the development of a flexible planning system for process monitoring and maintenance of Industrial Information Systems;
- Support for operation of process units by personnel with medium or low qualification levels;
- Training of technological personnel, providing an effective platform for the development of specialized operator simulators.

Conclusion

The experience of leading companies in the field of Automated Process Control Systems (APCS) shows that even a relatively small amount of information may be sufficient to develop an adequate model and optimize the control of a technological process at an industrial enterprise.

The effect of such improvement is quite measurable. The difference between the average values of the target parameter before the implementation of a virtual analyzer with optimization capabilities and after the establishment of an APC system can range from several percentage points to tenths of a percent. Over the course of a year, this difference may translate into thousands of tons of additional product, which can be easily expressed in monetary terms, thus clearly demonstrating that the costs of developing and implementing the system are economically justified.

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