The system analysis of multiassortmental manufacturings of phosphorus – containing products based on CALS – technologie
European Congress of Chemical Engineering (ECCE-6)
Copenhagen, 16-20 September 2007

The system analysis of multiassortmental manufacturings of phosphorus – containing products based on CALS – technologies

A. Bessarabov[a], L. Puigjaner[b], E. Koltsova[c], T. Ogorodnikova[a]

[a]*The State Scientific-Research Institute of Chemical Reagents and High Purity Chemical Substances (IREA) Bogorodsky Val, 3, 107076, Moscow, Russia;*
[b]*Universitat Politecnica de Catalunya, Avda. Diagonal 647, Pab. G-2, E-08028 Barcelona, Spain*
[c]*Mendeleev University of Chemical Technology of Russia, Miusskaya square, 9, 125047 Moscow, Russia*

1. Summary

An information system has been designed for monitoring the quality of multiassortmental manufacturings of phosphorus – containing products substances. The information system is based on the international CALS standard (ISO-10303 STEP). It contains the following information for the main elements of analytical monitoring: a list of elements to be monitored (substance classifier), details of the analytical procedure (including the sampling and sample preparation steps), performance parameters of the instruments, metrological support, and normative documentation (GOST standards, technical specifications, and others).

Keywords: phosphorus-containing products, multi-assortimental manufacturings, CALS, ISO 10303, system analysis

2. Extended Abstract

Multi-assortimental manufacturings phosphorus-containing products were examined. The first manufacturing consists of four products production by phosphoric slag processing. Four target products are examined during the investigation: sodium hipophosphite, sodium phosphite and lead dibasic lead phosphite and phosphorous acid received at further processing. Second manufacturing is a multiassortmental five-products manufacturing of phosphoric acid of various qualifications (fig.1).

The technology on waste minimisation and utilisation in present phosphorus chemical industries is definitely outdated and unable to face the environmental problems. In our work we try to mingle the best expertise in the area of phosphorus chemistry with the latest advances in computer-aided tools for synthesis, design and optimisation to lead to new technologies in the production of new useful products from waste generated from the production of phosphoric acid. The wide class of new sustainable production technologies will bring tremendous changes in the environmental impact of relevant industries and furthermore increase their

competitiveness. The main aim is the development of ecologically sustainable, environmentally friendly, resource and energy saving industrial process technology for the production of a wide-class of phosphorus-containing substances. The project focuses on new technologies of waste minimisation and utilisation of phosphoric slag production and processing.

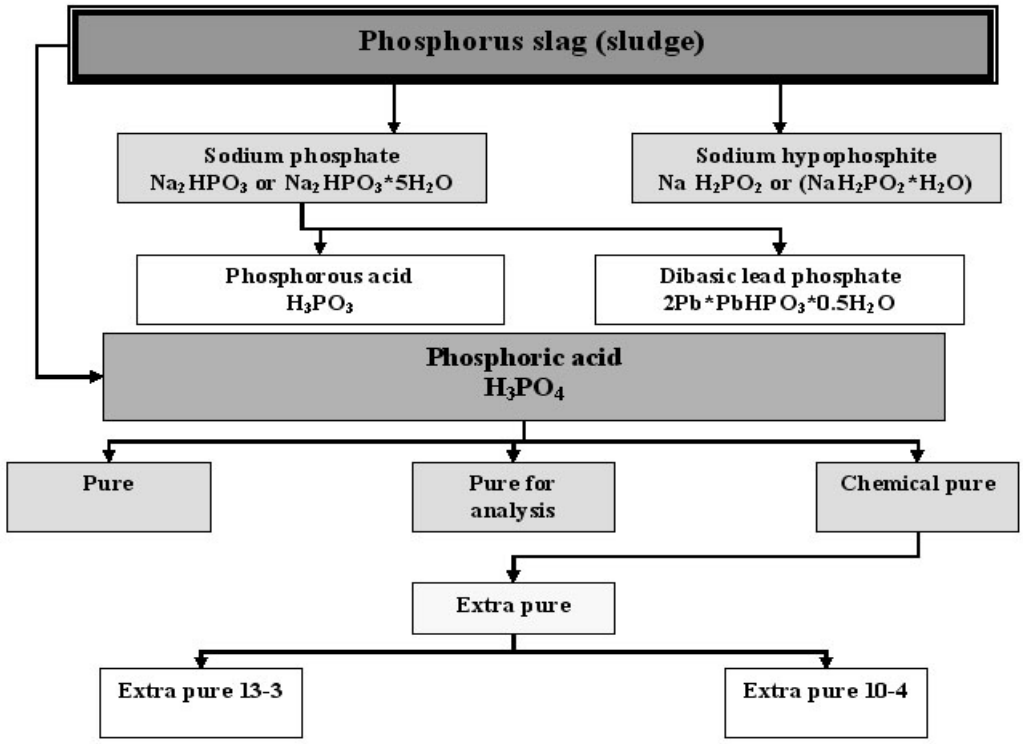

Fig. 1. Scheme of multiassortmental manufacturing of phosphorus containing products

The system analysis at four levels of hierarchy is made: nomenclature level, productional-technological level, organizational-technological level and organizational-productional level. Three kinds of flexibility correspond to hierarchical structure: technological, structural and organizational. (fig.2).

The organizational-technological level's attribute is a united compartment. Tasks: apparature optimization and production cycle minimization.

The organizational-productional level's attribute is a separate workshop as a complex cybernetical system. Tasks: stabilization of material and informational flows between the united compartments; distribution of raw materials, energetical and human resources.

The productional-technological level's attribute is a multiassortmental production. Tasks: optimal application of semiproducts and of common source materials; application of flexibility elements with the purpose of productional groups' extension; the power varying of the technological process in common.

The greatest interest for us represents a nomenclature level. Its characteristic attributes: a product of one aspect or one technological stage. Primal problems: expansion of a set of qualifications on parallax purity of one product; a variation of

power of a technological stage. The operation of the given level is ensured with technological flexibility, which is determined by ability on the available equipment to execute some technological problems at the expense of flexible technological methods of deriving of preset substances (under the nomenclature) or at insignificant expenditures on returning of the equipment (stopping on washing, recommunication of pipelines and other operations).

1. THE ORGANIZATIONAL-PRODUCTIONAL LEVEL	
Attributes	Separate workshop as a complex cybernetical system
Tasks	Stabilization of material and informational flows between the united compartments; distribution of raw materials, energetical and human resources

2. THE ORGANIZATIONAL-TECHNOLOGICAL LEVEL	
Attributes	United compartment
Tasks	Apparature optimization and production cycle minimization

3. THE PRODUCTIONAL-TECHNOLOGICAL LEVEL	
Attributes	Multiassortmental production
Tasks	Optimal application of semiproducts and of common source materials; application of flexibility elements with the purpose of productional groups' extension; the power varying of the technological process in common.

4. THE NOMENCLATURE LEVEL	
Attributes	Single-type production or one technological stage
Tasks	Extension of qualifications set for product's purity; technological stage power varying

Fig. 2. System analysis of (4-levels) multiassortmental manufacturing of phosphorus containing products

For system analysis and control information of phosphorus-containing products, there carried out the development of a software package, including standard output documents (GOST (State Standards of Russian Federation), TU (technical standards), protocols, certificates etc.). Development was carried out within frameworks of the most modern and perspective computer aided system - CALS-technologies (Continuous Acquisition and Life cycle Support). In the basis of the CALS concept there is a complex of uniform informational models, standardization of methods to access information and its correct interpretation according to international standards (ISO-10303 STEP). In our work, the CALS concept usage allows to accomplish effective analytical monitoring of a wide class of phosphorus-containing products, essentially reduce time of analytical research and to increase quality of performed scientific operations.

In the pilot CALS project based on system analysis approach, the initial information is classified into the following groups:

- analyte;
- impurities;

- analytical procedure;
- documentation.

Each group is hierarchically subdivided onto several subgroups. For example, the first group, Analyte (Substance), includes phosphoric acid and phosphorus slag (sludge). The phosphorus slag (sludge) treatment yields sodium hypophosphite and sodium phosphite. Further, sodium phosphite treatment gives dibasic lead phosphite and phosphorous acid (fig. 3). This classification of phosphoric acid is in line with the Russian Federation National Standard Classifier, which is a part of the Russian Federation Unified System of Classification and Encoding of Technico-Economical, and Social Information. It is also consistent with the International Standard Classifier.

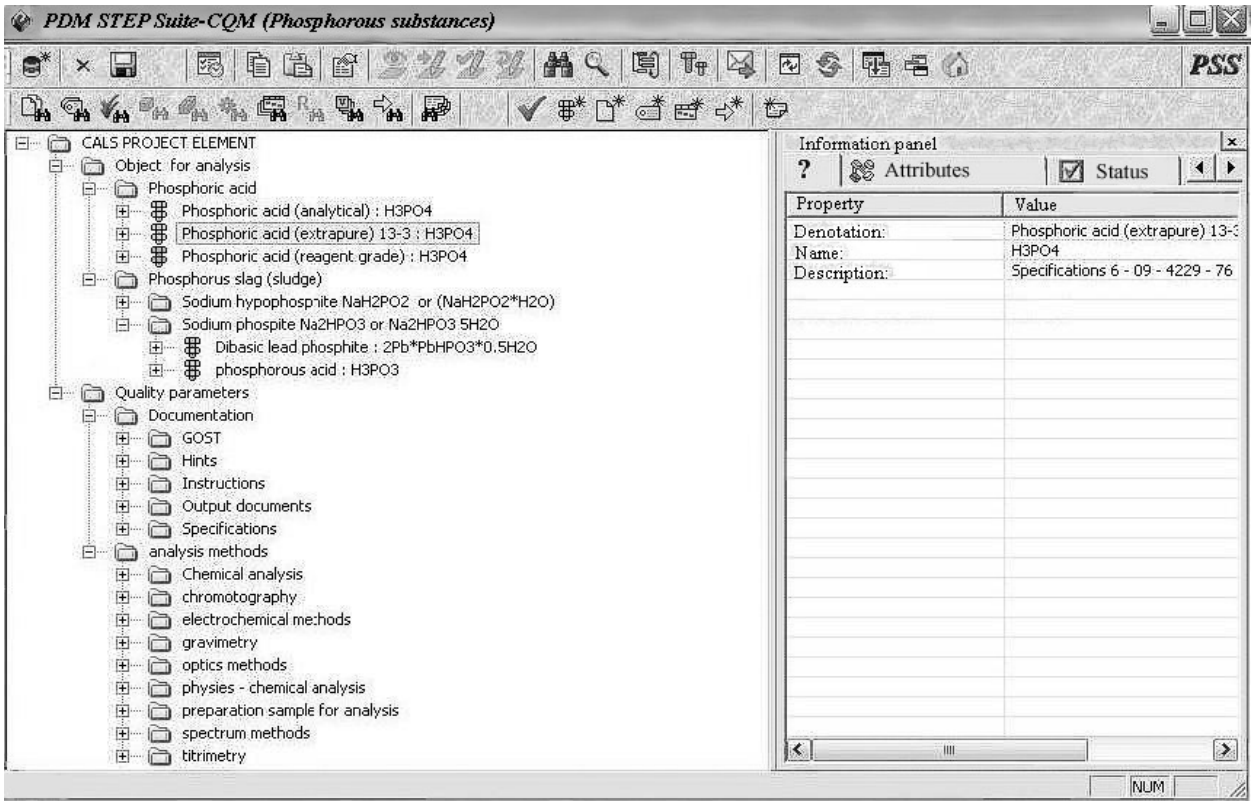

Fig. 3. CALS-PROJECT quality system management for multiassortmental manufacturing of phosphorus-containing products

The developed system has a hierarchical structure of databases (substances, normative and technical documentation, etc.) and is supplied with a user-friendly interface. Each functional unit has its special procedures and visual forms, including a set of modern information representation elements and interaction options.

The CALS system provides solutions to some of the associated problems:

- automatic order of materials and spare parts
- planning and control on maintenance work
- diagnostics of equipment and trouble shooting
- supply of reference data on the design and operating principles of equipment
- delivery of reference data necessary for running the equipment, performing maintenance work, and repairing instruments
- supply of personnel data (number and qualification)
- training of personnel to run, maintain and repair the equipment

The developed typical CALS project is a set of functional models involving a description of the sample life-cycle stages, monitored at the analytical laboratory. In the pilot CALS project, these models represent typical computer structures: marketing, design, manufacturing, operation, repair and others. Determination of the structure of stored data and software interfaces using the international CALS-standard makes it possible to simultaneously retrieve necessary information from different knowledge domains and to integrate the system with any other information system.
At the marketing stage, it is necessary to carry out certain actions to explore the market of high-purity substances, to compare the products with Russian and foreign analogues, to specify the potential customer's requirements on quality, to plan measures towards the necessary analytical monitoring, to establish steps intended to upgrade existing technologies and promote the product on the market, to study the user's requirements and potential manufacturer's abilities regarding the control on limiting impurities, to study the effect of such impurities on the properties of the high-purity substance and the operation of related tools .
At the design stage, one considers existing sampling, and characterization techniques and carries out research towards creation of new, more advanced techniques.
The manufacturing stage involves the laboratory measures. In addition, this stage includes internal and external quality control analysis in agreement with the relevant metrological requirements, including those on statistical data processing.
The operation stage involves the use and maintenance of equipment and the documentation involved. This stage also includes disposal steps, in particular, normative and technical documentation on the disposal of investigated samples with dangerous properties (toxic, explosive, flammable, etc.).
The repair stage is structured at three levels:

- malfunction of the analytical equipment
- malfunction source
- correction method for the malfunction.

The CALS system allows one to easily find a substance of the desired grade using a standard classification (fig.3). Next, a normative documentation is searched for by its definition for each controlled impurity. This enables rapidly gaining information about the analytical technique and equipment of interest, together with typical output documents .
The use of the CALS standard in designing monitoring information systems allows one to enhance the effectiveness of data processing and, hence, the quality and speed of analyses. Therefore, CALS technology offers the possibility of considerably reducing the cost of analyses and enhance its quality and serviceability. On the whole, this information technology allows one to create not only an effective quality control system meeting international standards but also an effective system for coordinating the analytical centers involved throughout the research and production cycle.

Potential users of such information include workers and supervisors at science and production institutions, inspecting state bodies, investors, etc

The support of EC Project ECOPHOS (contract № INCO-CT-2005-013359) is sincerely acknowledged

References

Bessarabov, A. M. and Zhdanovich, O. A., (2005) *Inorganic Materials,* 41, 1236–1242.

Bessarabov, A. M., Zhdanovich, O. A., Yaroshenko, A. M. and Zaikov, G. E., (2007) *Oxidation Communications,* 30, 206–214.