Applied Aspects of Using OSTIS Technology in Information Support of Digitalisation of Water Use Processes of Dairy Processing Enterprises

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***Abstract*—The conceptual approaches of digitalisation of manufactures based on the e-Manufacturing ideology are evaluated, which are proposed to be used for modelling the processes of water use of milk processing enterprises; the organisational and technological processes of formation of pollutants in their wastewater are analysed. In IDEF0 methodology functional modelling of water use of such productions is carried out, that allowed to reveal complexity and multidirectionality of interrelations of parameters and to justify the use of OSTIS technology for tasks of formation of intellectual information and reference system. On the example of a biological pond as a node of wastewater treatment, an element of the proposed approach of practical implementation of OSTIS-solutions in the segments of digital modelling of the dairy industry and environmental management is implemented.**

***Keywords*—Digitalisation, water management, milk processing, information and reference system**

I. Introduction

The term Digitale Fabrik (digital factory) is used to describe production in the context of informatisation, but today the essence of Digitale Fabrik is more often expressed by the term e-Manufacturing. At the heart of the idea of e-Manufacturing is the continuous application of digital models in the design and operation of production systems. Not only the products themselves are modelled, but also production equipment, material flows, as well as production and logistics processes, taking ergonomics and human factors into account. The goal of e-Manufacturing is to achieve such a level of object and process modelling that the real manufacturing process starts only after all its elements have been studied and optimised with the help of models [1].

Digital manufacturing is one of the components of product lifecycle management (PLM) technology, its main task is to improve complex manufacturing processes. A set of digital manufacturing solutions belongs to the class of MRM-systems (Manufacturing Process Management) [2].

If in CAD/CAM/CAE-systems in most cases the application of a particular software tool is associated with obtaining a digital layout of the product and the distribution of roles is clearly deterministic by the content of the work performed (surface designer, layout designer, solid geometry designer, etc.), in MRM-systems this dependence is much more flexible [3]. This is due to the fact that technological processes in different industries can differ significantly, even enterprises of the same industry can have different technological processes. Such operations include the functioning of complexes ensuring the fulfilment of environmental requirements, including the removal (treatment, discharge) of industrial wastewater (WW) [4], [5].

This problem is especially acute for enterprises of milk processing industry.

II. Technological problems of formation and treatment of wastewater of milk processing enterprises

Contaminated wastewater of milk processing plants is a product formed after washing of equipment, technological piping system, transport tanks of different volumes, including road and railway tanks, flasks and other containers [6], [7]. Also the sources of pollutants formation include effluents after cleaning of production facilities, washing of panels and floors. The amount of polluted wastewater is 20use. Wastewaters of milk processing enterprises belong to the category of highly concentrated organic pollutants: they contain significant concentrations of organic pollutants (fat, protein, lactose), polluted also with inorganic compounds (including acids and alkalis) and synthetic surface active substances (detergents). Their composition and concentration of pollutants depend on the profile and productivity of enterprises [7], [8].

Analysis of literature sources [4]–[8] has shown that there is an intensive search for rational and highly efficient methods and technologies of wastewater treatment for food industry enterprises (including dairy industry). The most common solution in this area is the combination of classical treatment methods with new methods [8], while an adequate choice of equipment for a particular enterprise is impossible without a high-quality design task and the preparation of appropriate models (first of all, water technological passport), including those based on digital technologies [9].

III. Problem formulation for an intelligent information and reference system water use by dairy processing enterprises

To solve the problem, we initially perform functional modelling in IDEF0 methodology (Fig. III).

The following categories of parameters (according to IDEF0 terminology) are selected on the basis of technological analysis:

- **input factors**
  - coming from measuring instruments in operational mode:
    - actual flow rate of process water (PW):;
    - about 2-3 process water quality indicators (e.g., pH, electrical conductivity);
    - actual wastewater flow rate;
    - about 3-5 quality indicators of WW: pH, temperature, redox potential (ORP), chemical oxygen demand (COD), electrical conductivity;
    - information on equipment status (based on the production scheme and operating SCADA).
  - measurements of water quality parameters from the laboratory:
    - information on PW quality;
    - information on WW quality.
  - from expert technologists and expert technicians:
    - information on the planned demand for PW per shift;
    - information on the planned demand for ingredients per shift;
    - information on the state of technological equipment.
- **control factors:** requirements for the quality of PW, characteristics of the equipment (under which it operates according to its passport parameters), requirements for technological processes (under which the requirements for their regulatory flow are met), regulatory requirements for the quality of wastewater, cost of resources;
- **mechanisms:** electrical equipment that ensures the operation of the information system as a whole;
- **results:**
  - dynamic balance of water use (based on planned shift production tasks, as well as with the function of calculating financial costs for the period from the beginning of the shift to the current point in time - potentially a forecast is also necessary based on the current state, for example, until the end of the shift);
  - operational forecast of the quality of WW (based on planned shift tasks, as well as with a forecast correction function based on real indicators of production and quality of PW and WW at the current time (with various forecast projections);
  - dynamic recommendations for organizational, technical and technological actions in order to reduce financial costs for water use (based on the current situation and forecast);
  - dynamic costs for minimizing waste pollution (based on the current situation and forecast).

Performing a decomposition of the first level diagram (see Fig. 1) allows you to detail the tasks of digital modeling (1Fig. III).

Analysis of the diagram of the first level of decomposition (1 see Fig. III):

- here the key will be the multi-level decomposition of the block “Systematization of data on water disposal parameters”, it will include production subsystems and units that use “process water”, polluting it and transforming it into “waste water” - with the main module “Intelligent information and reference system” (IIRS), which will analyze the situation and ”consult” process and technical specialists: what operating modes they should choose initially, how to relate to the state of this or that equipment (the flow of production processes), what variants of the assortment task will lead to what resource costs and environmental risks, regarding the resource cost of a specific assortment task, regarding the acceptability of the functioning of a specific unit or the use of an ingredient, etc. (based on a retrospective production analysis);
- at the same time, the “Intelligent Information and Reference System” must, of course, work with the integrating technology support block “Analysis and forecasting of the efficiency of use of water resources of an enterprise.”

The “intelligent information and reference system”, in fact, should become an adaptive (interactive) technological regulation for water use of an enterprise, largely ensuring the interoperability of the entire system as a whole, with potential transformation along the chain: “decision support system – automated process control system for water use — digital MES (MIS, LIMS, EMI) resources — ERP.”

Then the intelligent information and reference system for supporting specialists of milk processing enterprises in the water use segment is a software product (SP) intended for storage in a structured electronic form and prompt provision to other SPs and specialists of various technological information accumulated both in basic regulatory documents (BC ,SS R, BAT) and in specially created databases and knowledge. IISS will make it possible to create a unified information space of technological knowledge for prompt consultation on issues of interest to specialized specialists (managers, chief engineers, WW technologists, instrumentation and control engineers, designers) using data from regulatory documents and advanced solutions obtained, for example, based on benchmarking and expert opinions.

Main planned products:

- software (SP), which can be used by all enterprises, including holding companies;
- educational and methodological materials for continuous improvement of qualifications and retraining of specialists in the field of digital technologies using the created product.

At the same time, it should be noted that water use processes, including the functioning of local treatment facilities, are characterized by nonlinear-

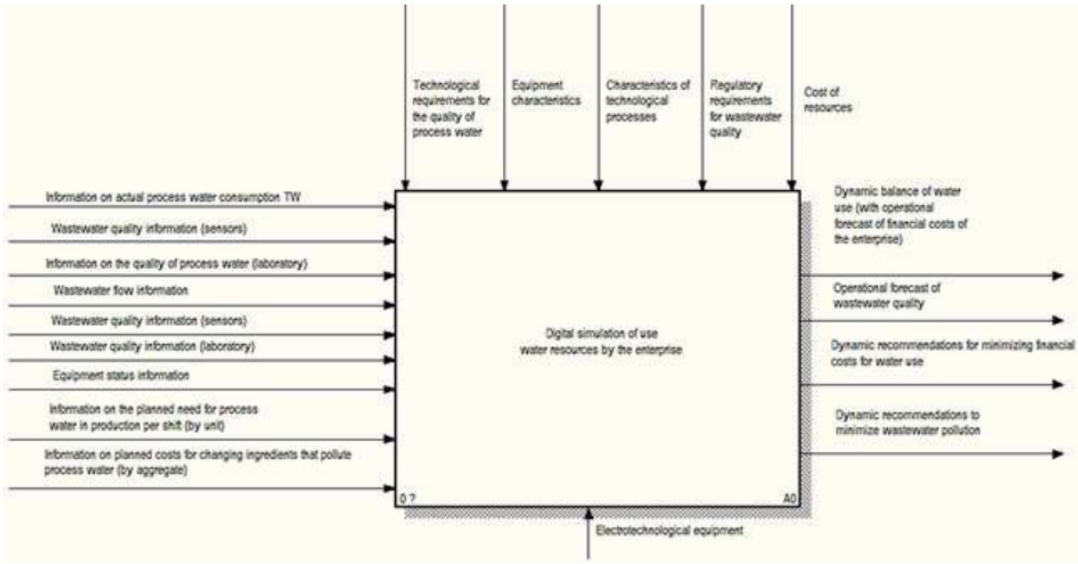

Figure 1. Context diagram for modeling water use of a milk processing plant

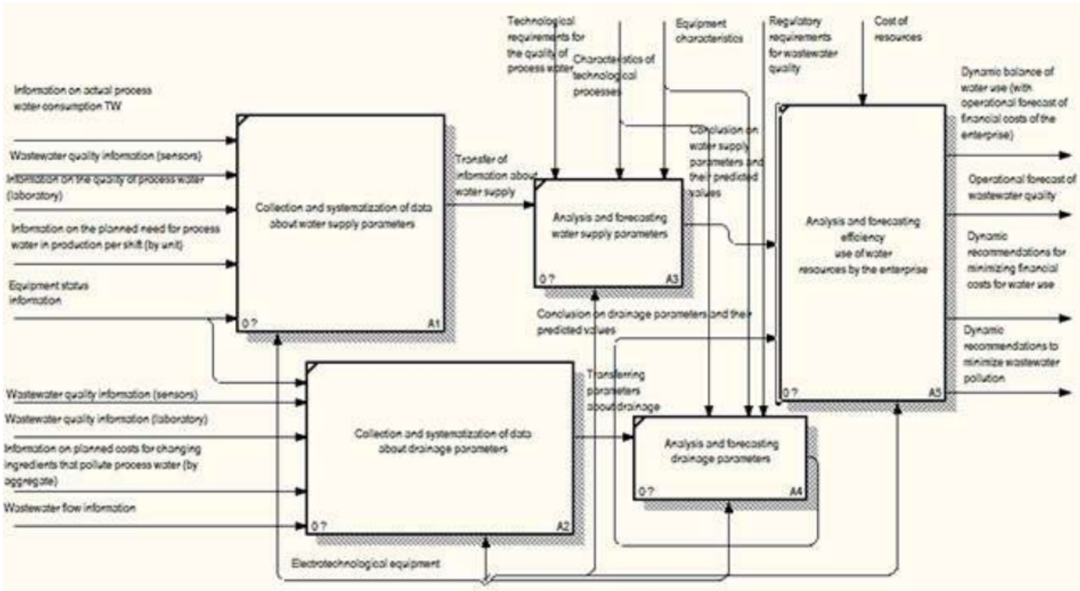

Figure 2. First level of context diagram decomposition

Figure 1: gfk

ity, nonstationarity, multifactorial, multiprocess nature, constant changes in the structure of internal relationships, the presence of significant hidden mutual influences between technological parameters, the use of separately functioning ones when solving a single industrial problems of information systems (for example, 5-6 industrial SCADA) [4]–[9].

Accordingly, the proposed (reasonable) transformation ("intelligent decision support system – automated process control system for water use — digital MES (MIS, LIMS, EMI) resources — ERP") requires a specialized methodological apparatus of a new generation.

Such solutions include OSTIS Technology [10]. New generation intelligent computer systems developed on its basis are called OSTIS systems. The OSTIS Technology is based on a universal method of semantic representation (coding) of information in the memory of intelligent computer systems, called the SC code. SC code texts (sc-texts, sc-constructions) are unified semantic networks with a basic set-theoretic interpretation. Elements of such semantic networks are called sc-elements (sc-nodes and sc-connectors, which, in turn, depending on their orientation, can be sc-arcs or sc-edges). The universality and unification of the SC code makes it possible to describe on its basis any type of knowledge and any methods for solving problems, which, in turn, greatly simplifies their integration both within one system and within a group of such systems.

The basis of the knowledge base developed using the OSTIS Technology is a hierarchical system.