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Research and Development of Smart Factory for Biotech Products in the Kyrgyz Republic

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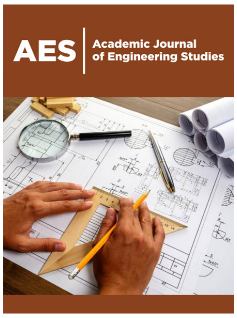

Abstract

The paper describes a general overview of a Kyrgyz-Russian research project for the SCO member states agro-industrial sector. The project objective and key ideas have been highlighted. Premixes as biologically active substances have been taken as a biotech product. Have been shown the role of humic acids in the composition of premixes as livestock feeding additives. The Industrial cyber-physical systems and cloud-based service for premix composition design models for Smart Factory for biotech products have been proposed and described.

Keywords: Humic acids; Nutrition premixes; Smart manufacturing; Smart factory; ICPS; Industrial cyber physical system

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Introduction

The current situation in the Kyrgyz agro-industrial sector shows weakness to new global challenges due to the pandemic situation. There are many issues, which demand fundamental investigation and search for new ideas and practical-oriented results. New multidisciplinary research based on advances in the latest state-of-the-art innovation fields would create new opportunities for development of SCO-member states industrial sector. Today, agricultural sectors such as livestock, poultry, and fish farming have become almost completely dependent on high technologies needed to improve, accelerate, increase the growth, development, and productivity of livestock, poultry, or fish. Feed additives play a special role in the success of the breeding process and innovative feeding methods. The current state of the problem that has developed in the Kyrgyzstan agro-industrial sector indicates that only through the active development of domestic scientific potential can the development of agriculture be possible. The research project objective is to create a technological framework and an architecture model for biotechnological Smart Factory in order to support and encourage exponential growth of SCO-member states sustainability and prosperity. Thus, there are several key ideas, which navigates our research:

1. Apply the ICPS paradigm to transform traditional solutions and technologies for bioengineering industries, at particular agro-industrial sector.

2. Ensure high production processes efficiency and respect for the unique natural environment of the Kyrgyz Republic.

3. Apply the proposed technical solutions for organizing the production process of biotechnological synthesis of complex compounds – multifunctional premixes based on humic substances, isolated from brown coal Kyzul-Kia/Kara-Keche (Kyrgyzstan).

4. Create a flexible manufacturing enterprise that can produce customized products in a wide range and batch size (multifunctional premixes) for the agro-industrial sector.

Background. Premixes and Humic acids

Premix is a homogeneous mixture of biologically active substances in the filler, which is used in the production of ready-made compound feeds, feed mixes or as an independent component of the diet. The composition of the premix, depending on the recipe, includes vitamins, trace elements, some amino acids, enzymes, preventive and therapeutic drugs, as well as other biologically active substances [1,2]. The main tasks of the premix production of premixes are accurate dosing, high-quality mixing and uniform distribution of the BAS minimum doses of in each portion of the mixture, as well as maintaining the activity of the added additives during the product life cycle. These tasks determine the specifics and technology of premix production.

The general production process consists of 6 stages: components preparation (sorting, milling, cleaning), additives injection, filler matrix injection, diluent injection, premix dozing and mixing, product packaging.

In the production of premix, the choice of filler is important. The filler must be well combined with vitamins and salts, but also retain biologically active substances on its surface as much as possible in order to maintain the homogeneity of the mixture during mixing and transportation and prevent self-sorting. It should also have a low humidity, which ensures the flowability of the mixture and better preservation of biologically active substances [3,4]. The prospects of using humic acid macromolecules for obtaining biologically active substances of a wide spectrum of action are determined by their polyfunctionality, which causes high reactivity and sorption capacity, as well as the presence of protective, transport and accumulative properties. The ability of humic acids to bind both metal ions and organic ecotoxicants in polluted and soil environments into strong complexes should be noted. In addition to these properties, they have such qualities as hydrophilicity, ion exchange ability, surface activity, which positively affect the absorption of feed nutrients in the animal body [2-4]. Humic acids from oxidized brown coal of the Kyzyl-Kiya deposit (Kyrgyzstan) have been used in the research study as premix matrix. Native humic materials were obtained using sodium humate from brown coal.

Results. Industrial cyber-physical systems for Smart Factory for biotech products

Industrial Cyber-Physical Systems (ICPS) are a state-of-the-art innovative field of research and development of new generation production systems engineering. In general, ICPS is understood as a technical systems network, which consists of the next interacting subsystems: digital (virtual) and physical (operational) components [5,6]. Applicable for bioengineering and biotechnology, as parts of engineering sciences, the I-CPS technology could provide a new way for multidisciplinary collaboration between the wide scope of engineers and specialists form chemistry, biology, production automation, data analysts and many others. In particular, new I-CPS design approaches and the Smart Factory paradigm could become extremely efficient in biotechnology industries taking into account its complexity, safety regulation, and dynamics. These industries will be able to create new personalized products for users based on new information and operational technologies, in accordance with the high dynamics of changing consumer requirements and market expectations [7,8].

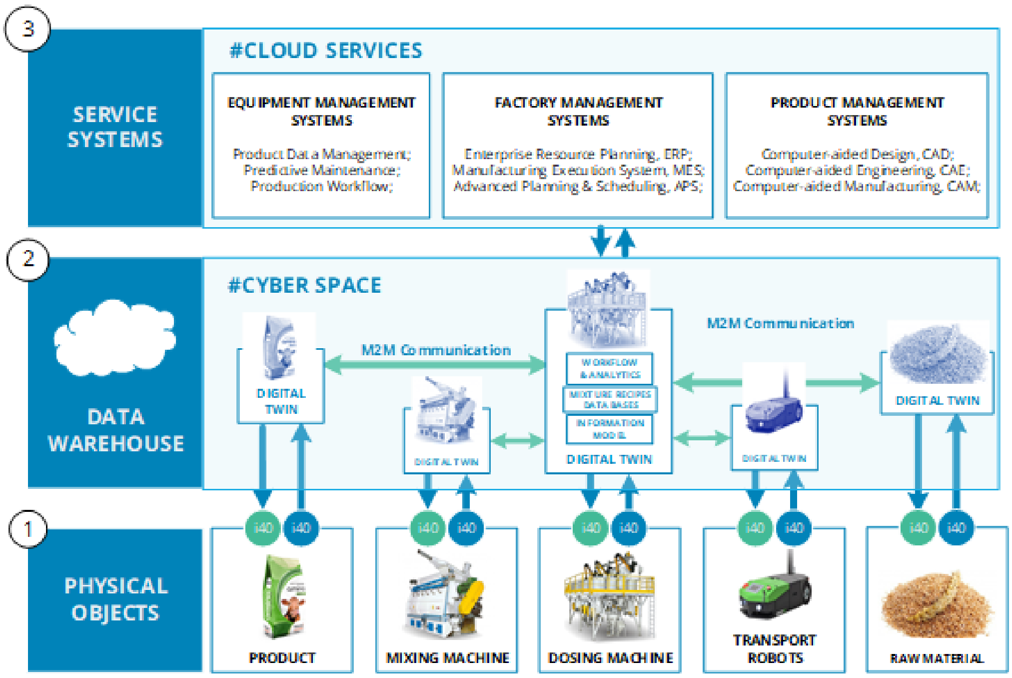

Figure 1: The model of Industrial cyber physical system for Biotech Smart Factory.

Proposed Smart Factory model Figure 1 consists of three layers – service systems, data warehouse, and physical objects [9]. This is a key for I-CPS organization and understanding. Physical entities have their real-time digital representations-digital twins. It's important, that every of the digital twin should has its embedded feedback loop due to update its status, their own workflow logic, data bases, informational models, and interfaces. It allows to communicate in united digital ecosystem as intellectual agents. It is equal for raw materials, products, production cells with equipment units, and robots. The cyber layer forms a digital space for the Smart Factory ecosystem. The cyber level is dedicated to support intellectual agents to communicate, integrate, and exchange their data and services throw the industrial network.

The core of the solution consists of a United data model, which is stored in products, processes, and resources Data warehouse. This data units are also stored in cyber layer. Integration topology is the main aspect for establishing communication in decentralized, flexible, and Reconfigurable production model. On this slide you can see that our production cells, assets, and technological equipment is going to be connected via Machine-to-machine (M2M-communication Net). Human and any machine, or product, which are connected to the united digital ecosystem through standardized M2M and Human-machine interfaces (HMI). The standardized semantic and syntax become important requirements.

The cloud service layer forms the last layer which allows to use general and special services for design, engineering, management, and etc. Most of the services has general specialization, which could be interoperable for any industrial application. Hence, each industrial application forms its special list of services – requirements for a cloud service layer composition. In agro-industry it's important to have a way to create non-standard products, which could face to special requirements formed by agro-tech engineers. It means that we need be capable to produce special premixes for special purposes, for example, mineral-enriched cattle feeding premixes or medical premixes. Proposed cloud service for premix composition designer is illustrated on Figure 2. This service has been designed to develop and virtually test new premix composition and its processing technology. Based on Computer-aided design and simulation software, this service would provide finite process workflow specification with optimized parameters.

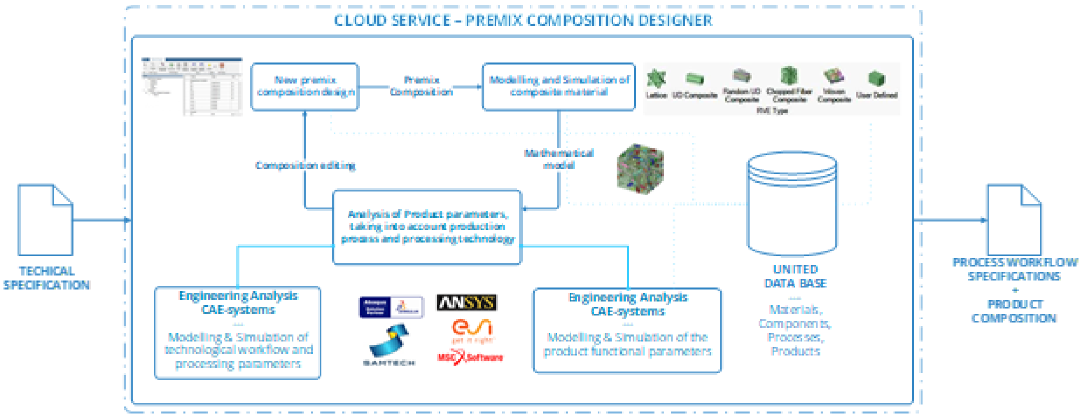

Figure 2: The model of cloud service "Premix composition designer".

Discussion & Conclusion

ICPS could be understood as a technical systems network, which consists of the next interacting subsystems: digital (virtual) and physical (operational) components. ICPS could form a platform for cross-industrial multifunctional applications, due to its flexibility, pluggability and interoperability. Current project research cooperation is based on two major research partners: Kyrgyz National University n.a. J. Balasagyn, Bishkek, The Kyrgyz Republic and ITMO University, Saint-Peterburg, The Russian Federation. Both partners have formed a collaboration based on a distributed research team. The first research group from Kyrgyz National University under professor Anar A. Zaripova scientific supervising is working on the next research domains-chemical technology of premixes, processing workflow and technological operations, material design fundamentals. The second research group from ITMO University under professor Eugeny I. Yablochnikov scientific supervising is working on the next research domains technological processes automatization, Smart Factory model and architecture, digital design, and industrial engineering. The research team tactical objective is to finish a Smart Factory prototype on the test-bed and validate theoretical hypothesizes. The project collective is open to research and industrial cooperation with institutions and organizations from SCO-member states.

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