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Editorial

Editorial: Digital transformation in process and equipment management at Fuel and Energy Complex and Mineral Resources companies

In the context of the rapid development of digital technologies and increasing demands on energy efficiency, sustainability and competitiveness of industrial enterprises, the fuel and energy (FEC) and mineral resources (MR) complexes are undergoing major changes. Digital transformation is becoming a key factor in improving the efficiency, reliability, and sustainability of production processes, as well as an important element of the strategy for technological sovereignty and the modernization of production systems. Modern approaches to managing equipment and process chains are based on the use of machine learning methods, big data analysis, digital modeling, and the creation of digital twins, which, in turn, allows not only the optimization of technological and business processes, but also the formation of new control architectures from local systems to industrial metauniverses.

This thematic volume presents research studies united by the common theme of digital transformation at fuel and energy complex and mineral resources companies. It covers three key areas: energy, oil and gas, and mining and metallurgy, demonstrating a wide range of applications of end-to-end digital technologies, from load identification to reservoir property prediction and the creation of ontological enterprise models.

Incorporation of three key industries in one volume suggests that digital transformation today extends beyond individual automated systems, creating a holistic ecosystem of intelligent industrial process control with the potential for sustainable lifecycle management of energy and mineral resources.

The articles presented reflect both fundamental scientific research and practical solutions in demand in the context of import substitution and the growth of domestic technological potential. Particular attention is paid to the interpretability of models, economic efficiency, and practical applicability of solutions. The materials in this volume will be useful to a wide range of specialists – scientists, engineers, business managers, and software developers – working in the field of industrial digitalization and will serve as a stimulus for further research and implementation.

The “Energy and Energy Efficiency” section presents research aimed at improving the energy efficiency of electrical complexes of industrial enterprises.

The article by *Yuriy L. Zhukovskiy* and *Pavel K. Suslikov* is devoted to the identification and classification of the electrical load of mining enterprises based on signal decomposition, which makes it possible to create conditions for the classification of loads for the purpose of implementing electricity demand management.

Aleksandr V. Nikolaev and *Aleksei V. Kychkin* propose a service for managing electricity demand for ventilation in underground workings, opening up opportunities for adaptive regulation of energy consumption.

Natalia I. Koteleva, *Vladislav V. Valnev*, *Aleksandr S. Simakov* and *Maysam M. Shirazi* examine the process of creating a cyber-physical service engineer avatar as the basis for constructing an industrial metauniverse where physical and digital processes interact in a single information space.

Roman R. Khalikov, *Mikhail Yu. Chernetskiy*, *Ilia E. Revin* and *Vadim A. Potemkin* propose an automated machine learning technology using a model composition framework for fault detection in pumping systems based on motor current signature analysis.

Irina Yu. Semykina, *Valery M. Zavyalov*, *Yaroslava A. Nechiporenko* and *Elena N. Taran* develop a model of wireless charging infrastructure for battery-powered dump trucks at open-pit mining enterprises, which is relevant for improving environmental efficiency and reducing the use of diesel fuel.

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The "Oil and Gas Industry" section examines the use of digital technologies to improve drilling efficiency, production, and environmental safety.

Vasiliy I. Nikitin, *Mikhail V. Dvoynikov*, *Kirill S. Kupavykh* and *Tatiana A. Panteleeva* model the influence of rheological parameters of nonlinear viscous drilling mud on the quality of cuttings removal using machine learning methods.

Andrei V. Soromotin and *Dmitrii A. Martyushev* apply machine learning approaches to modeling synthetic hydrodynamic well tests and predicting the permeability of oil formations.

Ildar M. Ishkulov and *Irik G. Fattakhov* use interpretable machine learning to detect well leaks, providing not only high prediction accuracy but also an understanding of the causes of defects.

Pavel S. Tsvetkov proposes a cluster approach to capture and transport of industrial CO_2 demonstrating economic advantages due to the effects of scale when combining stationary emission sources into a single network with a shared infrastructure.

The "Mining and Metallurgical Industry" section presents solutions for digitalization of ore flow management, geoinformation support, and equipment localization.

Sergei A. Deryabin and *Igor O. Temkin* develop an ontological model for the digital transformation of mining enterprise architecture, which allows for the formalization of knowledge and ensures consistency between IT systems.

Egor A. Knyazkin, *Dmitrii A. Klebanov* and *Roman O. Yuvakaev* propose new methods for assessing the variability of the quality of minerals based on big data analysis to improve the efficiency of the produced quality of minerals.

Sergei V. Lukichev and *Oleg V. Nagovitsyn* highlight the development of MGIS, demonstrating the practical results of the implementation of modern geographic information systems in large mining companies.

Mikhail S. Nikitenko, *Danila Yu. Khudonogov* and *Sergei A. Kizilov* examine alternative approaches to determining the position of equipment in quarries to solve dispatching and navigation problems within technological areas for the operation of highly automated vehicles without the use of navigation equipment.

Onalethata Saubi, *Rodrigo S. Jamisola Jr.*, *Raymond S. Suglo* and *Oduetse Matsebe* predict and optimize particle size distribution in blasting waste using hybrid artificial intelligence methods at a diamond mine contributing to improved overburden mining efficiency.

Sergei V. Khokhlov presents alternative approaches to digital modeling of blasted rock muckpile, which allows for the prediction of particle size distribution and optimization of subsequent processing.

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