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Creation of Technology for Building Automated Production with Remote Control (Industry 4.0 Concept)

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Abstract

Production processes at technological enterprises often face many problems. One of the main problems is the failure of the mechanisms involved in the technological cycle, errors that occur during the operation of the system associated with data loss or incorrectly defined parameters, etc.
To solve a limited number of problems arising at technological enterprises with automatic control, based on KIAM Russian Academy of Sciences, the International Laboratory "Sensorika" with the assistance of partners, a complex to produce experimental products was created. This complex allows not only to produce test samples of innovative materials, but also, in turn, allows conducting research to improve the reliability of the technological process. In a fairly short period of time, our specialists have developed and implemented control systems for the manufacturing, sorting and transportation of products.
The developed dispatching systems allow intelligent analysis by means of distributed control of multiple controllers integrated into a single data exchange network. Each of the controllers allows you to interrogate dozens of sensor devices responsible for the processes, collecting positioning data, engines speeds, temperature, and pressure in tanks, etc. The obtained data is analyzed and allow to organize feedback from that technological equipment, in which it is not possible to conduct a direct survey of the state.
The use of the distributed control principles opens opportunities for maximum scalability of all production processes. Processes in which a person plays an important role are equipped with an adaptive interface, that opens the possibility to conduct logical analysis and remote monitoring, at a higher level to determine failure situations in conditions of a large range of products, manufactured according to experimental recipes.

Keywords: industry 4.0 concept; automation of technological processes; logical analysis; sensorics; PLC.

1. Introduction

When developing and creating industrial and civil complexes with an automated process control system, it is customary to use a standard architecture conditionally divided into three levels: information (upper level), control (middle level) and executive (lower level). Each of the levels differs from each other in the functions, performed in the system architecture and is regulated by the normative document GOST standard 34.201-2020. The interaction between the levels takes place via fieldbus or local area networks. Often, when choosing the concept of building a system and architecture, it is impossible to conduct a complete examination of the condition of the executive elements of production equipment. Without receiving data related to the state of the actuators, mechanisms can fail, directly increasing the likelihood of defective products.

To solve such problems based on KIAM Russian Academy of Sciences, the International Laboratory "Sensorika" with the assistance of partners, a complex to produce experimental products was created. During the development and creation of this complex, the approach of phased implementation and commissioning of production sectors was chosen. To date, the production complex includes: a suspension base preparation unit, a suspension synthesis unit, and a transport conveyor [1], [2],[3]. This complex allows not only to produce test samples and production of innovative materials, but also, in turn, allows conducting research to improve the reliability of the technological process.

2. Suspension-base preparation unit

The result of the study to improve the reliability of the technological process of suspension preparation was the development of special software, that allows you simultaneously monitor all control actions, coming from the operator, the technologist and has the control logic unit with the ability to analyze the presence of contradictions, thereby eliminating the occurrence of emergency[4],[5],[6] [7],[8],[9],[10].

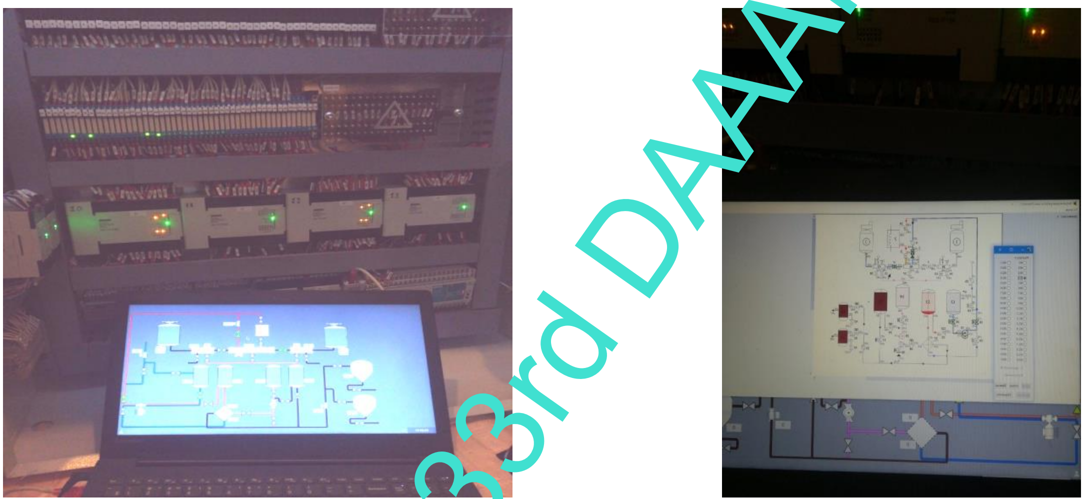

Fig. 1. Test of the algorithm for logical analysis of the technological process of manufacturing and casting finished raw materials into molds.

The software interface of the implemented program was created in the Delphi integrated development environment. The software, after analyzing based on the logic of branching time, visually displays more rational options for the implementation of the technological process, to achieve maximum efficiency of the selected recipe. Figure 2 shows the result of the logical analysis of the technological process by the system - interface displays in real time the operation process in the PLC (programmable logic controller), according to the specified parameters [11],[12],[13]. In that case, we find the optimal solution of the problem of filling the steam generator has been determined: it was necessary to control the corresponding valves.

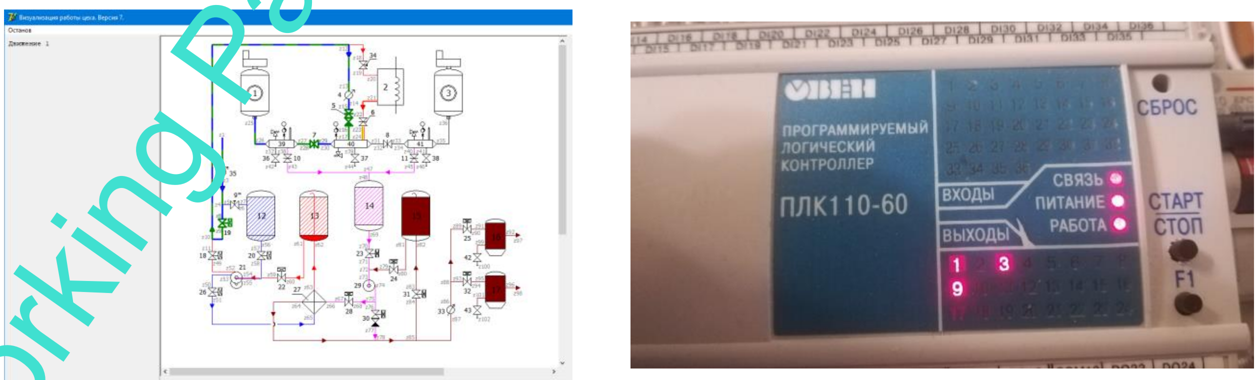

Fig. 2. Visualization of the algorithm for logical analysis of the technological process

of manufacturing and casting of the finished raw materials into molds.

3. Suspension synthesis unit

This year, a new suspension synthesis plant started the operations. Several studies were conducted to determine the critical conditions of the equipment. As the result of research, we've developed an appropriate system architecture and assembled the electronic rack-box for sensors monitoring and control of power units up to 22 kW (Figure 3).

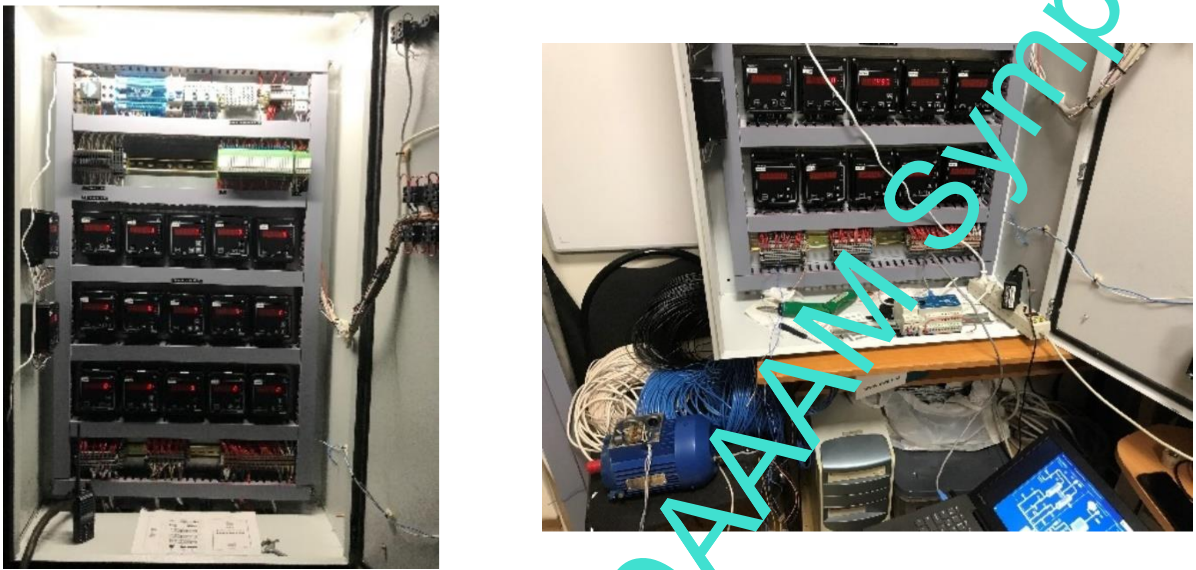

Fig. 3. Montage and testing of the electronic rack-box for monitoring and control of power units.

The conducted studies of power units have shown that the main reason for the failure of power units is the jamming of moving parts during operation, which leads to a complete shutdown of the system and the failure of several engines [14],[15],[16],[17]. The way out of this situation was to modernize the some working elements of the engines, inject sensors, because of it, became possible to control the engine speed and compare them with the reference ones for the corresponding unit. Thus, when the parameters deviate from the nominal ones, the system analyzes, shows what happened, and generates signals about it.

At large production facilities a vibration monitoring system for aggregates was used for the same purpose, but the accuracy of the measured parameters, in this way, was not optimally accurate and can lead to a false alarm, when working near the power unit. Figure 3 (on the right) shows the testing of a system with a connected power unit standing next to it [18],[19]. Also, the result of receiving feedback from power units was the ability to control the volume of bulk additives using indirect data with an accuracy of up to a hundred grams without using additional weighing equipment, i.e., by receiving readings from a single actuator and performing calculations from temperature, pressure, etc. The use of such sensors, make possible to evaluate the concentrations and properties of the suspension without resorting to chemical analyses of specialized laboratories.

4. Transport conveyor

To date, a transport conveyor is being prepared for launching into test operation. Engine control algorithms (about 100 units) are being investigated in accordance with the law of trapezoidal change of speed [20],[21],[22]. Due to the need to consider many different parameters of mobile trolleys/platforms on conveyor rails (loading, wear of drive parts, etc.), it is necessary to pay special attention to the calculations of the moments of approach to the acceleration and braking sections to maintain a constant speed, as well as a smooth stop and start of movement. Earlier, we developed a corresponding application package with a simulation model of the process and integrated it into the system. Thanks to this package, it becomes possible to analyze the state of each mechatronic modules in the complex and adjust of the production scenarios. In addition, a line of executive consoles has been assembled for testing the movement of trolleys/platforms in real production conditions (Figure 4).

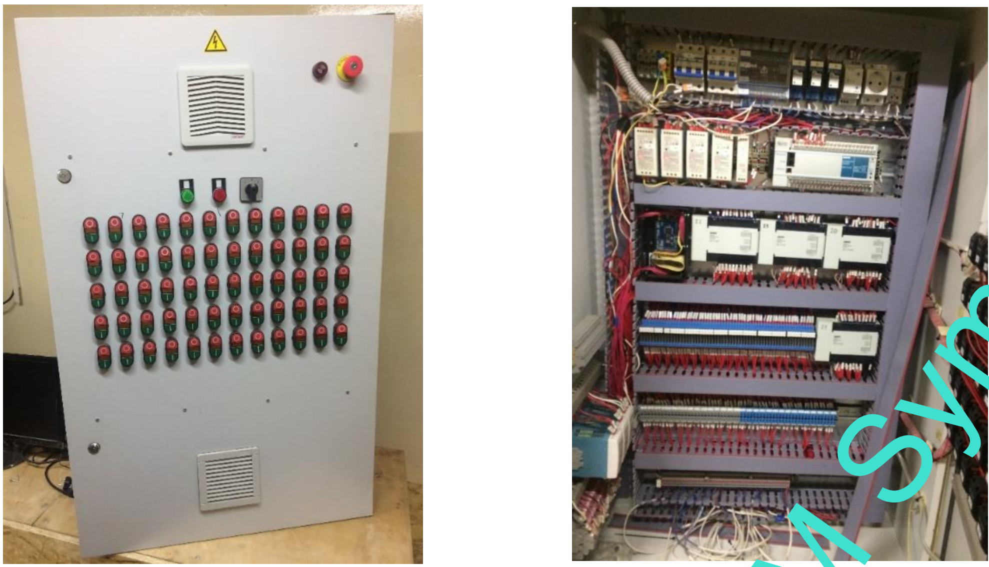

Fig. 4. Remote control for testing of industrial vehicles motion

The upper level of visualization of the entire complex is based on the generally accepted SCADA system interface for industrial enterprises. The SCADA system includes a set of control settings for selecting recipes and making changes to them [23],[24],[25]. The operator could control part of the actuators, depending on the state of the technological process. Each keystroke requires confirmation, and an event log is kept not only of the use of the operator's interface, but also all control posts on the territory of the industrial cluster. The use of the event logs of the state of equipment and actuators, as well as the presence of a video surveillance system, play one of the main roles in the industrial safety of the enterprise [26],[27],[28],[29]. The administrative staff has remote access to the video surveillance system and the enterprise monitoring system, using the cloud services implemented at the enterprise, Figure 5 [30],[31],[32],[33].

Fig. 5. Interface of the system for industrial production monitoring and control.

5. Conclusion

The created software and hardware implement typical processes, that take place in a significant part of the control systems of smart factories, built based on the concept of Industry 4.0. Thus, the data obtained from the implemented software and hardware are a good example of creating a technological base, a constructive approach to the organization of intelligent industries and other similar industrial applications. The system in automatic mode successfully calculates the results of the control algorithms and issues recommendations to the operator and technologist, based on which the automated process can work flawlessly and produce high-quality products.

Further horizons of planning the development of the system consist in the complete exclusion of a person from the production cycle of production. The main idea is a web interface on the consumer side, where a potential buyer can configure the required number of products himself, as well as make his wishes, the logical analysis system will adjust the production process itself. At the exit, you can get a finished product, packaged and ready for further transportation.

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