Monitoring and forecasting the operations of the transport complex of the enterprise

Vitaliy Kuzmin
Samara National Research University
Samara, Russia
vskuzmin28@gmail.com

Dmitrii Elenev
Samara National Research University
Samara, Russia
ORCID: 0000-0001-5073-2988

***Abstract*—An automated system of a transport complex is used to model the transport complex of the enterprise basing on the example of nuclear power plant. The complex provides transportation of containers with fuel and radioactive elements through the sealed enclosure of the reactor building. The parameters of the transport complex are determined by its constituent objects, namely gates, roads, transportation devices and controllers. A web-based intranet application was developed for monitoring and control purposes. The application works on the basis of the values of current conditions. The operator panel allows to notify if the current state requires intervention of staff. The system processes signals of analogue and discrete origin, as well as system signals from the programmable controller. Basing on the changes of main parameters, it is possible to predict the service lifetime of individual elements.**

Keywords—transport complex, monitoring, forecasting, web application, discrete signals, analogue signals

I. Introduction

The transport complex carts the cargo through the territory of the enterprise and is described by the following typical elements: rail tracks, sliding gates, doors, gateway, transport trolleys, programmable logic controller.

Usually the researches refer to the transporting the cargo outside the perimeter of the organization, modelling the logistics and allowing the monitoring of the process of the transportation between remote objects and premises [1, 2]. The railways, sea and air transportations are significant part of these global models [3, 4]. Sometimes the transportation of cargo requires to use more than one vehicle to transport one large element of cargo, and this can be useful to improve the reliability when transporting dangerous cargos [5].

The modelling is made for the transport complex of the nuclear plant, where all typical elements listed above are used and the cargo is carted through the airtight fencing of the reactor building with all necessary security procedures. This example of the nuclear plant allows to use extended list of components and parameters of the transport complex [6].

The monitoring and forecasting are based on the web application which, by use of the database of states of the transport complex, allows to predict possible faults of elements and to notify the operator before the incident occurs. This web application automates the workflow of the transport complex.

II. Methods used for monitoring

The automated system uses a system of objects included into the model of the enterprise, namely: airtight zone, describing the reactor building; gateway which allows to move cargo into and out from the reactor building; non-airtight zone, which describes the area outside the reactor building; and the zone of loading and unloading the cargo.

The parameters of the transport complex for forecasting purpose are displayed on the operator panel with an allowance of subsequent notifications.

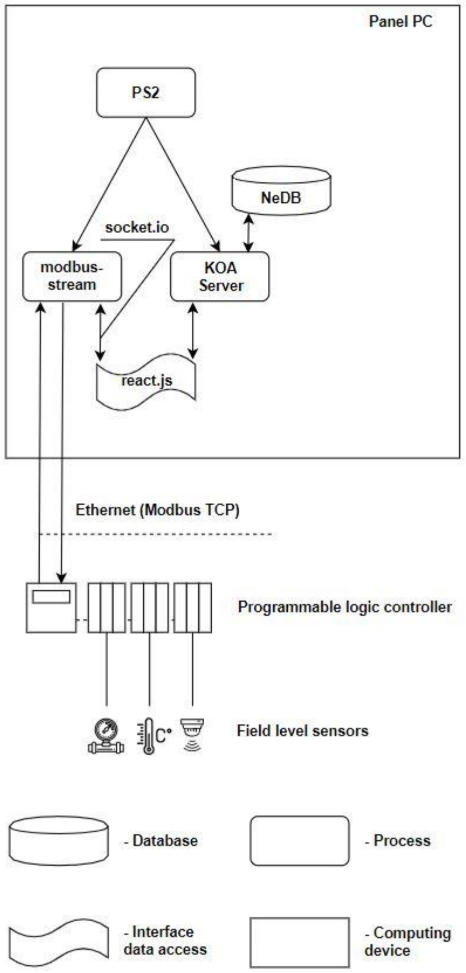

Fig. 1. The architecture of the system.

Input signals can be of discrete or analog origin. Discrete signals are provided by limit switches for the rail track, responsible for the current location of the transport trolley; electric drives of the trolley and for the sliding gates; electromagnetic brake for transport trolley; switches and sensors on actuators; flashing light and howler for sliding gates. Analogue signals are provided by pressure valve sensors and by the limit switches of the emergency exit of the main gateway.

System signals from a programmable logic controller include the CPU load level, battery level, and system errors.

The architecture of the automated system is shown in Fig. 1. The automated system consists of three levels, where the first, the lowest level is based on measuring instruments, sensors and activators, the middle level includes programmable logic controller, counters and programmable relays, and the highest level is the operator panel, or PC panel [7, 8].

The analogue and discrete signals are received by the programmable logic controller, and after processing they are transferred to the operator panel using Ethernet ModBus TCP interface.

After the data is requested from the programmable logic controller and sent back, received data is inserted into the database, and the values of input and output signals are updated in the user interface. If there is no answer from the controller during the pre-defined time, the application records this as an error in console event log.

The connection between web application and the programmable logic controller is made using the event oriented JavaScript library, allowing to update data real-time. Server side is supported by the NodeJS modulus, which transfers the received signals to the application by usage of Ethernet ModBus TCP interface. The web application is accessed by the web browser on the operator PC, and the web application transfers and saves information about the events to the server database. Therefore, server side of the application uses NodeJS, Node-modbus-stream, KOA HTTP Server and NeDB modules to operate, and processes and transfer data from the programmable logical controller.

The stability of operation of the server side of the web application is provided by the process service, which monitors the processes and restarts them if needed.

The client side of the automated system is developed using NodeJS as a development environment which provides the correct operations of the components, a Socket.IO library which allows real-time data exchange, PS2 component to monitor the serviceability of program modules, and the React framework to make visualization [9].

Fig. 2 depicts, for better visibility, the prototype of the user interface. User interface illustrates the current technological process including the discrete values received from the sensors, states of the airtight and non-airtight zones gateways and sliding gates, power state, states of the switches, etc.

The user interface shows the values of analogue sensors, the state of programmable logical controller and gives an access to the event logs. All data shown is real-time, and this means that the user interfaces depicts the technological process of the transport complex dynamically.

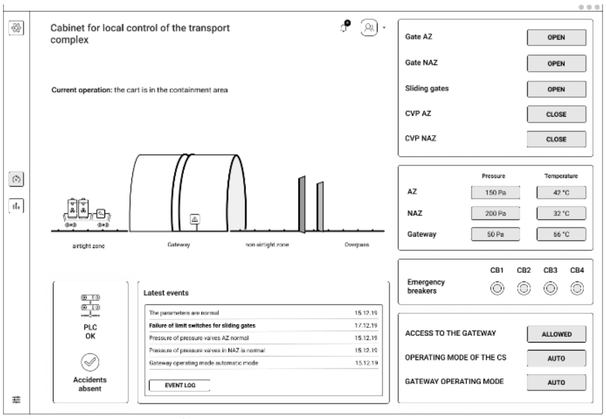

Fig. 2. Monitoring interface.

Fig. 3 shows the state of the status of the actuators in the user interface. The actuators are grouped by their placement – in the airtight area or in non-airtight area. The information about each actuator includes the operation time of the limit switches and pressure valves. It is also possible to define limit values, or set points, for the parameters of the actuators.

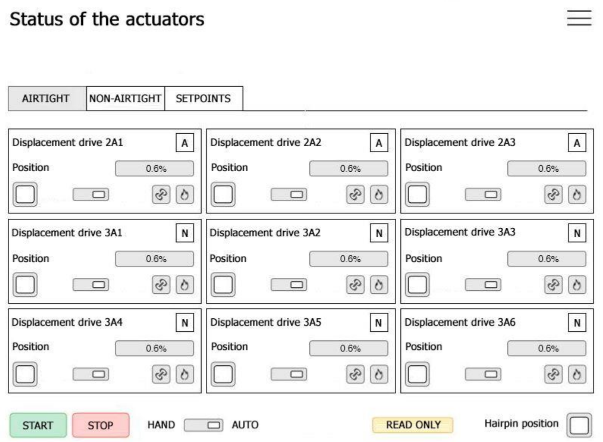

Fig. 3. Status of the actuators.

III. Forecasting

Basing on the results of data collection, the algorithms of forecasting the crucial changes in states of main elements of the transport complex were developed. These algorithms are aimed at providing emergency messages to operators and uses the statistics on duration and intensity of usage of elements. These statistics are hardly accessed without the automated system, and the algorithms allows to predict possible failures and upcoming end of the lifetime of the elements [10].

The main page of the forecasting module is shown in Fig. 4. The visualization is made using graphs and diagrams describing the parameters of the transport complex. The functions of the forecasting module include the creation of the parameter, the collection of the statistics, data import and export, filtering and sorting of parameters. To avoid the input of the incorrect parameter values, the alert modal windows are used. The web interface allows to change the placement of graphs and indicators, edit the preferences of each graph and to export the data used for the graph in the external file. In the left lower corner in Fig. 4 the overall information about values in pressure valves is shown, and if these values reach pre-defined limits, the operator is being warned.

Fig. 4. Forecasting interface.

The web-based application automates the workflow of the transport complex, allowing to collect the statistics from the event log database. This data gives the ability to forecast the change in state of parameter and to warn the operators about possible emergency events. One of the examples of the emergency event is the necessity to change the sensor before it became inoperable thus reducing the interruptions in the workflow of the enterprise.

IV. Conclusion

The automated system realizes the monitoring and forecasting procedures for the operations of the transport complex of the enterprise. These procedures allow to reduce the scheduled repair time by reducing the time spent on diagnostics of individual elements at their installation sites. The system also allows to reduce the number of unplanned emergency repairs as a result of permanent monitoring of states of elements of the system. The novelty is the modelling of the internal transportation process within the enterprise and the software allowing to forecast the states of the elements of the transport complex.

The considered method of automation the transport complex can be used in different areas, for example, during carting bulk materials in granaries [11].

The forecasting uses the characteristics of the elements of the transport complex given by their manufacturers, complemented by parameters defined at the stage of development of the complex.

The system visualizes the state of the system, allowing the operator to monitor the system status real-time, thus providing fast reaction on change in parameters of the system. The automated system models the workflow of elements and the whole transport complex.

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