Experience of development and implementation of integrated intelligent control system for Ustyurt gas-chemical complex

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Abstract

Examines the experience of development and implementation of integrated intelligent control system (IICS) for Ustyurt Gas-chemical Complex, which combines control systems of five industrial enterprises with different profiles on a single hardware and software platform. It is also highlighted an innovative approach to the implementation of the project of such level of complexity based on the concept of system of project management for integrated informational-control systems (SPM IIS).

Keywords: integrated intelligent control system (IICS); system of project management for integrated informational-control systems (SPM IIS); Ustyurt Gas-chemical Complex (UGCC)

1. Introduction

The project of Construction of Ustyurt Gas-Chemical Complex is the largest project in the industrial branch, implemented today on the territory of the Republic of Uzbekistan. The implementation of this project, having no analogues in the country in its complexity and scale, has become a serious challenge for specialists of gas industry of the Republic. Especially valuable is the success of this project made at the appropriate level of quality and in strict compliance with the deadline.

During the phase of analysis of inputs for development of the concept of the project of construction of Ustyurt Gas-Chemical Complex, a group of engineers, consisting of specialists of Automation Department of JV "Uz-Kor

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Gas Chemical" and specialists of the Korean and Uzbek divisions of Honeywell company, immediately faced with two strategic challenges that require unique to our country methodological solutions for the implementation of projects in the field of automation and informatization.

First, the organizational-technical challenge of coordinating the interaction with three General contractors for engineering, supply and construction (Samsung Engineering Co. LTD, GS Engineering & Construction Corp., Hyundai Engineering Co. LTD).

Second, the scientific-technical objective to create a centralized integrated intelligent management system that combines information-control systems of five industrial enterprises.

The settling of these tasks was found in the applying of the specialized system of project management for integrated informational-control systems (SPM IIS), which was developed by "XIMAVTOMATIKA" Company, which is a subsidiary of Honeywell company in Uzbekistan.

2. Composition of the object of control

The project of Construction of Ustyurt Gas-Chemical Complex considers:
- Drilling of gas wells and construction of appropriate communications on the Surgil, North and East Berdakh fields to the South of the existing Aral Sea;
- The construction and operation of the Ustyurt gas-chemical complex near the village of Kyrkkyz/Akchalak on the Ustyurt plateau, and the related infrastructure;
- The construction and operation of underground pipelines to transport gas and condensate fields in the gas-chemical complex.

Ustyurt Gas-Chemical Complex is a manufacturing conglomerate that combines 5 industrial plants:
- Plant for the separation of natural gas coming from Surgil field
- Plant for production of Ethylene
- Plant for the production of high density polyethylene
- Plant for the production of polypropylene
- Complex of industrial package equipment, combined into the utilities and off-sites auxiliary facilities.

Production capacity of the complex provides the technology of deep processing of natural gas in volume of 4.5 billion m³/year and gas condensate in amount of 162 thousand tons/year with extraction of following valuable components:
- production of fiscal gas amounted to 3.8 billion m³/year;
- production of high-density polyethylene – 387 thousand t/year;
- production of polypropylene – 83 thousand tons/year;
- distillate pyrolysis - 102 thousand t/year;
- pyrolysis oil - 8.3 tons/year.

3. The choice of the organizational-methodological solutions for the creation of integrated intelligent control system for Ustyurt Gas-Chemical Complex

According to the concept of system of project management of creation of integrated informational-control system (SPM IIS), development of the IIS project is carried out by using two basic approaches – structural and object. The first is based on the principle of algorithmic decomposition, when assigned to the functional elements of the system and sets a strict order of actions to be performed, and each module implements one of the steps of the overall process. The second approach is based on object decomposition and better adapted to the evolution model. The subject area is divided into a set of relatively independent objects, having properties and a set of applicable functions (methods). The concept of the object, thus, combines data (state) and functions (behavior).

SPM IIS Methodology determines the program of improvement of production activity of an industrial enterprise as a mega-project, i.e. a set of projects, characterized by a special complexity of products produced and methods of control. The major methods used in the development of improvement programs, are: method feasibility of design and regulatory balance method. This approach turns the art of designing and production management in the engineering discipline, since it represents a set of methods and tools designed to improve the basic indicators of activity of the object by modeling, analysis and redesign of existing business processes.
In the first phase of the project for the development or reconstruction and modernization of the system of industrial enterprise management, concept is developed for the management of its establishment and operation, which is determined by the objectives of management information system and requirements to it.

In the process of creation and functioning of the system of IIS project management (SPM) the structure of the SPM of the integrated information management system is developed and elaborates on the research field. Under the project in this case refers to a complex of actions for creation/reconstruction of the existing management system. The structure of the SPM IIS presents functional and subsystems interrelation between which is supported throughout the life cycle of the SPM. Phase establishment and functioning of the SPM IIS also regarded as a kind of project to apply methods of project management. The establishment of the project management is the concept of the design, installation/operation and development of control systems for industrial production.

SPM IIS Model should allow to harmonize the activities of subjects of management in a common information space at all stages of the life cycle of the object. The structure of the complexes object defines a subject area model of the IIS project management system and provides the chain of the technological process, from initial search of work to delivery of finished products to the consumer. Structural decomposition of the subject domain model of the information management system SPM provides an algorithmic description of the business process management for project creation or modernization and reconstruction of the IIS.

Developing the IIS SPM concept includes the creation of a documentary base defining a subject area model of the IIS project management system as the basis for decision-making on reconstruction of the IIS criteria-based assessment successful completion of the project.

The advantage of using a system model of a IIS is the possibility of more rapid and accurate response to the inevitable deviation of the actual and design parameters, as well as the possibility of assessing the accuracy of management information system. Economic gains from the manifestation of positive factors of using the IIS should depend on this accuracy and increase with its growth. On the other hand, the introduction of the of a IIS leads to the costs of creation and operation of the system. In such a situation the problem arises: to determine a value of the correct functioning of the information management system to the percentage of its use (the difference between the assessments of strengths and weaknesses) was the highest, which is necessary to formulate and solve the problems:

- the choice of criterion of economic efficiency from the creation and operation of information management system;
- definition of accuracy of a IIS;
- establishing the nature of the dependence of effects on the accuracy of the work of IIS;
- computation of magnitude of effects depending on the accuracy of the IIS;
- calculation based on the criterion of economic evaluation of the production and use of IIS on the accuracy of its work and determine the optimal value of this criterion and the corresponding optimal accuracy with the IIS.

The mathematical solution of these problems is both algebraic expression models the SPM IIS and is written as the following formula:

\[
F(Y_1, ..., Y_N, T_1, ..., T_N, f_1(x_{11}, ..., x_{1M}, y_{11}, ..., y_{1M}, z_{11}, ..., z_{1M}), ..., f_N(x_{N1}, ..., x_{NM}, y_{N1}, ..., y_{NM}, z_{N1}, ..., z_{NM})) =
\]

\[
= f_1(x_{11}, ..., x_{1M}, y_{11}, ..., y_{1M}, z_{11}, ..., z_{1M}) + \ldots + f_N(x_{N1}, ..., x_{NM}, y_{N1}, ..., y_{NM}, z_{N1}, ..., z_{NM}),
\]

where:

- \(Y_1..Y_N\) - quality at every stage;
- \(T_1..T_N\) - time provided for every stage;
- \(y_{ij}\) - quality (productivity) at i-stage with configuration j;
- \(t_{ij}\) - time at i-stage with configuration j;
- \(x_{ij}\) - number of personnel engaged at i-stage with configuration j;
- \(z_{ij}\) - number of money spent for i-stage with configuration j;
- \(f_1..f_N\) - project stages;
- \(\varphi(x_{ij}, y_{ij}, z_{ij})\) - time function.

Meanwhile

\[
f_i(x_{i1}, ..., x_{iM}, y_{i1}, ..., y_{iM}, z_{i1}, ..., z_{iM}) = t_{il} = \varphi(x_{il}, y_{il}, z_{il})
\]
and \( l \) is defined from following pre-requisite conditions:

1) \( |Y_i - y_{il}| < \varepsilon_1 \) – difference between real and required quality, when condition (1) is performed and condition (2) is checked etc.

2) \( \frac{Z_{il}}{y_{il}} - \min_{j=1,m} \frac{Z_{ij}}{y_{ij}} < \varepsilon_2 \) – money for the quality item minus minimum value

3) \( |T_{il} - t_{il}| < \varepsilon_3 \)

If conditions are not performed error to be raised.
If there are multiple solutions, error to be lowered.

\( \varepsilon_1, \varepsilon_2, \varepsilon_3 \) parameters depend on project manager.
There is such \( l \) that the conditions 1, 2, 3 in certain positions are performed.

This methodology has been applied in the development and implementation of the project of construction of Ustyurt Gas-chemical Complex and, as shown by the test of time, helped to implement plans on time and to the required quality level of the final result.

4. The choice of the technical solutions for the creation of integrated intelligent control system for Ustyurt Gas-Chemical Complex

The basic concept of integrated intelligent control system for the Ustyurt Gas Chemical Complex (UGCC IICS) is the construction of a centralized integrated information management system that combines automated control systems of five industrial plants with different profiles and providing the organization of a unified information space of the complex to ensure prompt dispatch and efficiency are taken by the management for strategic decisions on the management of the complex \([1]\).

To implement this concept, the set of technical solutions is selected based on the use of common hardware and software platform for automated management systems of all five enterprises of the complex. Hardware and software platform is based on the Experion PKS system (R410) \([2]\).

Platform consists of:
- Experion PKS server nodes responsible for the management of each of the individual industrial plant;
- Experion PKS operator stations united in groups of consoles;
- paired control equipment of middle level of management system presented by the DCS C300 model controllers and ESD SM model controllers;
- equipment interfaces with the local control systems package equipment, are provided by the generally accepted open Modbus protocol.

All server nodes are implemented in redundant configuration.

The exchange of information between EPKS server nodes of five industrial plants is performed with the help of Distributed Server Architecture (DSA) technology, which allows to combine the data (points, signals, messages, and history) into a single database. This scientific and technical solution ensures the achievement of the main goal of the project which is the centralization and seamless integration of the five management systems into one. DSA Technology actually provides one-time access to information from all monitoring points equipped with the appropriate station equipment with human-machine interface \([3]\).

In General, the control system is designed in such a way that each group of consoles works independently and does not depend on other groups of consoles. Even though the console group operate autonomously, separate operators of the technological process can view the information on demand from other groups of consoles.

The application of DSA technology is flawless in the case of this project, as it allows all nodes in the Experion system to use the process without the need of duplication on each of the pieces of equipment of the control system.

The station equipment and the equipment of server nodes are connected to a common redundant Fault Tolerant Ethernet (FTE) network. FTE Technology provides a fourfold redundancy of the routes of connections of all nodes in the network with each other. Thus, from the standpoint of modern achievements of scientific and technological progress, maximum possible level of reliability and security of industrial control systems is ensured.

This creates a one-piece cluster that is equipped with a function (again by the possibilities of DSA technology) to exchange information with other clusters, for example, with industrial facilities in oil and gas industry of the Republic with a single corporate center.
Another innovative solution, applied in the project of creation of UGCC IICS and directed to provide a total centralization and flexible integration of five systems into one, is the global data archive based on a Process Historian Database Server (PHD). This server provides the collection and transfer of information from all five EPKS servers in real time, and is a single point of access in real time to information for all the subsystems of manufacturing execution system (MES-system) level and enterprise asset management (EAM-systems) system level.

PHD Technology, which allows to collect data in real time, their archiving and historization, as well as providing tools for intelligent data processing and analysis, is an essential fundamental component of modern integrated information management system. Combining ease of use with the ability to detail the attributes of data processing PHD technology performs the following functions:

- Defining tags with the ability to track attributes of different classes;
- Collect real-time data simultaneously from multiple network nodes;
- Extensive Toolkit of data pre-treatment, advanced options to compress the amount of information;
- Multi-file and multi-layer system of long-term data archiving;
- Intelligent data extraction and manipulation tools to support information system requirements;
- Clear client-server interface for many different computing environments;
- Built-in mechanisms of calculation of values of virtual tags;
- Centralized system control through the PHD control program.

Thus, the creation of PHD technology-based single data warehouse for the whole complex of the UGCC also vividly describes the specifics of the project, subordinated to the achievement of the main goal of centralization and integration of five industrial plants into one industrial cluster.

5. Conclusion

Ustyurt Gas-chemical Complex commissioned in year 2016, can rightly be considered the largest project in the oil and gas industry of the Republic of Uzbekistan for the entire period of the newest history of our country. IICS system of complex is an example of transition of information technology in industry to the absolutely new level, requiring a rethinking of the approach to creation of information management systems. The creation of such a system would not be possible without the following factors:

- forward-thinking leadership of Ustyurt Gas-chemical Complex who have relied on the use of the most modern information technologies;
- SPM IIS methodology, was developed by specialists of the “XIMAVTOMATIKA” company and allowing to solve tasks in project implementation for IIS systems of any complexity;
- a set of innovative technical solutions from Honeywell that covers all intended functionality of the planned system concept.

The final success of this project is an achievement of the entire industry and allows us to plan the transmission of industry of our country to a new level of informatization and automatization.

References