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Implementation Of Intelligent Technologies For Managing Of Gas-Chemical Complex On The Example Of Uzbekistan Gas To Liquid (UZGTL) Project

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Abstract—*This paper provides summary of intelligent integrated solutions designed and considered to be implemented in coming future in Uzbekistan Gas to Liquid (UzGTL) plant. The main idea of design is to cover first priority functionality of the plant with innovative automation and information (IT) technologies, at the same time keeping the requirement of supporting by all these intelligent solutions openness for integration and standardization of interfaces to get possible deployment of overall plant lifecycle management system for future upgrades and extensions of enterprise.*

Keywords: *plant lifecycle management (PLM) system;Gas to Liquid (GTL); Process Automation system (PAS); Process Historian Database (PHD); Computerized Maintenance Management System (CMMS); production accounting; digitalization.*

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I. INTRODUCTION

Creation of holistic source of information that is structured properly and accessed for using and managing by different categories of design, operation and maintenance staff of the industrial enterprise is the key to achieve perfect model of plant from the safety, effectiveness ease of management point of view. But to achieve this in large-capacity oil and gas, gas- and petrochemical, chemical industrial spheres still several steps to be done and several years to be passed…

Some manufacturing branches, like aerospace industry, machinery construction, machine-tool construction, already achieved this goal, using new concepts of Continuous Acquisition and Lifecycle Support (CALS), Product Lifecycle Management (PLM), Product Data Management (PDM) and others. But we should understand that these branches as an output manufacturing result, finished producthave series of off-the-shelf items and manufacturing process of such items can be structured and standardized more easily using advanced Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM) software tools which are progressed in development very rapidly [1].

Oil and Gas, chemical enterprises require different conceptual approach for targeting of same idea, because they have significantly greater amount and variety of input, intermediate and output factors during production cycle, much deeper and difficult-to-control process, and involvement of biggest spectrum of different engineering specialties.From another point of view even advanced CAD/CAE/CAM software applications cannot cover required design functionality because modelling of some plant aspects cannot be described with standard mathematical functions and requires new level of software which use modern achievements of mathematic modelling in simulation and virtualization environments [2].

This paper is intended to demonstrate some of such intelligent solutions and hopefully will put one more brick in the foundation of new enterprise lifecycle management approach.

II. IMPLEMENTED INTELLIGENT SOLUTIONS

UzGTL complex is new Gas to Liquid (GTL) plant which is designed at the location adjacent to the existing Shurtan Gas Chemical Complex (SGCC) near to the town Qarshi in Southern Uzbekistan.
UzGTL complex is based on the application of highly innovative technology of chemical conversion of natural gas to the liquid fuels and another hydrocarbon product. Generally, it incorporates three core process steps:

1) Conversion of hydrocarbon gases into synthesis gas (a mixture of CO and H2)in the presence of steam and oxygen.
2) Conversion of the synthesis gas into longer chain liquid hydrocarbons bymeans of the Fischer-Tropsch (FT) reaction.
3) Upgrade of FT liquid products into high quality final products (mainly GTLDiesel, GTL Kerosene, GTL Naphtha and LPG).
The relationship and principal material flows between main process units of UzGTL complex are shown in Figure 1.

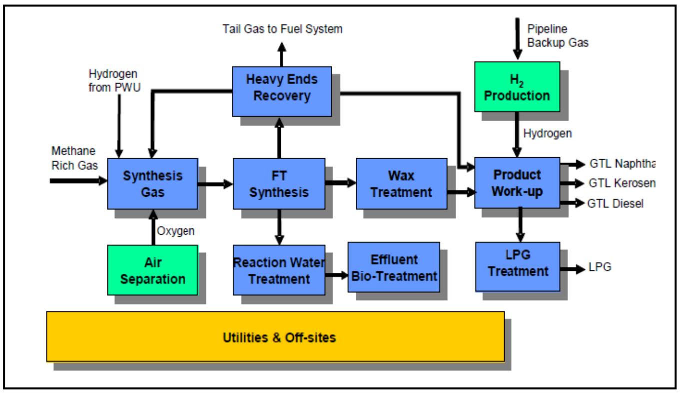

Fig. 1. Overall Block Flow Diagram of UzGTL complex

The basic concept of UzGTL complex considers to create one global space of information which integrate levels of Process Automation system (PAS), Information Management system (IM) and Business Information network (BIN). Information model includes following subsystems and internal interfaces designed or considered to be designed and seamlessly integrated in nearest future: Field Instruments, Programmable Logic Controllers (PLC), Instrumented Control and Safety System (ICSS), Condition Monitoring, Metering and Custody Transfer System, Analyzer Network, Process Historian, Asset Management, Computerized Maintenance Management System (CMMS), Fire and Gas detection System (FGS), Machine Monitoring and Protection System, Anti-Surge System, Rail Loading, Production Planning and Scheduling Systems, Production Accounting and Data Reconciliationsystem (PAS/DR), Plant Simulation Management Systems (PSM), Business Systems, Project Database Management, Plant Telecoms System, Access Control System (ACS), Environmental Management System (EMS), Laboratory Information Management System (LIMS), Plant Information Management System (PIMS), Logistics Information Systems (LIS), Close Circuit Television (CCTV), Enterprise Resource Planning (ERP) System, Financial Systems, Electronic Document Management System (EDMS).

The Central element ensuring well-coordinated work of integrated information model of the Uzbekistan Gas to Liquid (UzGTL) complex, from the point of view of the health of the entire IT-pyramid, is the real-time database (RTDB) server, implemented in the Process Historian Database (PHD) technical solution from Honeywell company. This PHD server platform provides interaction between all layers of IT-pyramid.

The main component of this architecture – Uniformance PHD server – is a software- hardware platform for collecting data from Experion servers on which the control system of technological processes is built, as well as, optionally, from other PHD servers, which are nodes of the control systems of other industrial objects. Thereby is provided an open interface for future integration into production clusters in the country scales. Also Uniformance PHD server is equipped with tools for visualizing and processing data for and by the users of the system.
Architecture of PHD is demonstrated at Figure 2.

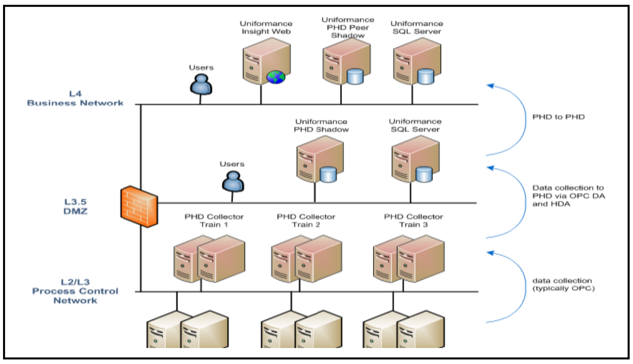

Fig. 2. Architecture of PHD technology

Architecture of PHD is constructed in accordance with the best practices and standards for cyber security of industrial object. Thus the role of node, providing direct data collection from Experion system, given to the component of PHD server which is called PHD Experion Collector, and which is physically located next to the Experion servers, and thus plays the role of a buffer node. Further, all data collected by the server PHD Experion Collector are duplicated (replicated) by PHD Shadow Server node that is located remotely from the Experion servers responsible for process control in a secure area separated from the area of process control with firewall. PHD Shadow Server stores data collected from multiple nodes of PHD Experion Collector in a single MS SQL database. It is through this database the user's access to the source of information[3].

In addition to the data acquisition PHD RTDB server platform provides the crucial function of providing data to all upper levels of the information model of the UzGTL complex.

For example, such an interface is provided for the system of production accounting which is included in the set of subsystems of the Manufacturing Execution System (MES) level and performs a number of critical tasks for the operational management of production and optimization of its work. The system of the production accounting or, other named, system of production data balance (PAS/DR) is designated to identify, reduce and, to some extent, rectify or compensate for the influence of random and gross errors associated with the measurements in the process. The measurement process may be incorrect, may demonstrate inconsistency or even conflict with other measurements on the same process stream or equipment. This is due to the fact that the sensing elements of the measurement devices are subject to impact of process noises and mechanical failures, which reduces the measurement accuracy[4].

System of production data balance uses a number of techniques to detect and remove random and gross errors, such as data cleaning techniques by means of statistical analysis, mathematical calculations, mass and energy balances, the algorithms of conditional optimization. All these methods are used to convert raw data from field devices in a "reconciled" data.

PAS/DR system of UzGTL complex is considered to be implemented based on Production Accounting and Reconciliation (PAR) solution from Honeywell company.

PAR allows quickly collect and organize production information and run data reconciliation scenarios against material movement and inventory models populated with process, quality and movement data. Using state-of-the-art, high-speed algorithms, PAR reconciles all available process, inventory and receipt/shipment measurements, taking into account the precision and accuracy of each instrument in the measurement system and ensures that the reconciled process measurements have minimum adjustment to the original measurements. PAR ensures that accountants, engineers, planners, maintenance and management can all work towards more profitable operations with the confidence they are using a single, consistent set of operating data as the basis for their monitoring and analysis tasks.

PAR achieves following benefits:

- Obtained material balance proportionate, accurate, and precise, based on data from the measurements in one processing unit.
- Improvements in operational planning using data that have been reconciled between the processing unit.
- Early detection of an error in the measurements shows the area where the error occurs specifically.
- Detection of missing transactions.
- Reducing losses are not recorded (unaccounted) by reducing error tools estimates flare metering and better.
- Getting a production accounting system up and running is easier and faster with a completely revamped model builder, anybody can use the intuitive graphical “Drag and Drop” Model builder to create/extend balance models of interest.
- Collecting data is easy - from historians, Hydrocarbon Products Movement Management systems, Lab systems, ERP, including in-built screens for operators to enter manual movements and tank levels.
- Reconciliation engineers will find their work much simpler as PAR churns out results faster with fewer errors. Innovative graphical interface guides the user to the problem areas and continuously tracks the balance quality. Revamped metrics enables the user to compare production data across multiple periods to identify patterns of disturbances. Individual flows can be compared across multiple periods to identify instrumentation errors. In-built approval workflows enable faster collaboration and a robust review of data.
- Enabled rapid dissemination of production accounting data across the organization, so that the true potential of the availability of the right data at the right time is exploited. Web based access and Interactive Production Metrics Dashboard enables a consistent assessment of production data. Excel based Ad-Hoc queries provides flexibility for users to create their own reports. Audit records ensure regulatory compliance requirements are met.
- Production Accounting reduces the Total Cost of Ownership. Built on the latest technology platform using standard Microsoft technologies such as IIS and SQL Server, it shares infrastructure with other applications (common security configuration, asset model configuration, data access configuration, etc.) It has eliminated

the need for Oracle and Crystal Reports and uses a True thin client interface built using HTML5, thus reducing the deployment foot print.

- PAR's powerful statistical data reconciliation engine rapidly performs the network balances and identifies gross errors using following mathematical principle:

$$\text{Minimize} \sum_{i=1}^{N} \left(\frac{\text{Reconciled}_i - \text{Measured}_i}{\text{Tolerance}_i} \right)^2$$

$$\text{Subject to } \sum \text{Input} - \sum \text{Output} + \Delta\text{Inventory} = 0$$

- PAR enables sites to calculate net mass or volumes of saleable product, including the removal of water, conforming to API/ASTM standards. Different tank types are supported, such as fixed and floating roof, bullet, horizontal tanks, spheres, and caverns.
- PAR also supports four independent statistical techniques for solving a balance model, which differ in the degree of rigorousness employed in theunderlying mathematical model, which in turn is reflected in the execution speed and accuracy of results (Regularization - Ridge Regression (RR), Newton Method, Singular Value Decomposition, NOVA Successive Quadratic Programming).
- A unique feature of Production Accounting and Reconciliation, is the Missing Movement Solver. Manual logging of movements at a plant site, sometimes results in failures to record individual movements. These movements then tend to cause large errors within the reconciliation. The missing movement detection algorithm evaluates each potential movement that is in the configuration but does not have any data for the balance period. Production Accounting and Reconciliation will then suggest likely movements that may have occurred, saving time and frustration.
- Using the reconciliation diagnostics, the reconciliation engineer is able to determine when reconciliation can be considered as completed, which is typically the case when incremental improvements in the balance quality become negligible. At this point the reconciliation engineer can save the results and close the balances. Closing a balance automatically triggers the recording, within PHD, of all reconciled values applicable to the model and accounting period under consideration. To support regulatory compliance requirements such as the Sarbanes Oxley Act, which require businesses to make sure that the financial data they present are authentic and auditable, PAR provides an inbuilt audit log which automatically captures all of the changes performed on the accounting period.

Another intelligent technology which is designed and considered to be implemented in UzGTL production complex is Computerized Maintenance Management System (CMMS).

CMMS is designed to facilitate the management and planning of events of maintenance and repair of equipment, with the goal to extend the period of operability of assets to reduce the use of spare parts and lower operating costs. It supports the day-to day activity of plant-wide maintenance and alleviates theworkload of the maintenance staff, reducing the paper work and increasing theefficiency of maintenance activities [5].

The CMMS system is based on a client/server infrastructure, with workstations (for Operations and Maintenance stuff) connected to the CMMS server. The CMMS server is also designed to be connected to monitoring and control systems such as DCS or PLC which may exchange information with the CMMS system, or may initiate maintenance activities. The user interface of all CMMS modules is efficient and easy to use in entering, editing, querying and viewing maintenance related data; it makes use of templates with pull-down menus, selection lists and fill-in blank fields, to be used to enter data and information contained in the module database.

The CMMS system of UzGTL complex is planned to comprise the following functions:

- Asset Management
- Work Orders Management and Follow-Up
- Warehouse Management
- Preventive Maintenance
- Predictive Maintenance
- Management of Periodic Plant Turnaround
- Inspection
- Reporting.

Scope of the Asset Management module is to archive information and data on every item of the Plant subject to maintenance (such as equipment or instrument). It will be described in more details in later part of this section because this module is core module of CMMS system in UzGTL plant and focuses around itself the work of other modules.

Work Order Management module allows following maintenance work orders, from initial request to completion. It allows initiating, tracking and recording all maintenance work orders and related data and results. It allows monitoring and analyzing the performance of maintenance work process in terms of resources employment, as well as materials and tools costs and usage.

The Work Order Management module supports both planned and unplanned maintenance activities: i.e. preventive maintenance, predictive maintenance, general plant turnarounds, as well as specific corrective maintenance. In details, it supports the following functions:

- Record, archive and retrieve work order requests along with all relevant data and information, such as:
  - identification number, date and time of the request;
  - equipment subject to work order;
  - type of work order request (e.g. preventive, predictive, corrective, etc.),
  - description of work to be done,
  - priority, schedule, progress and expected date for work completion,
  - resources allocation: manpower, tools, materials,
  - estimated cost and effective cost (after work completion),
  - safety related information (required work permits, actions and safety precautions to prevent accidents, specific hazards).
- Allow authorized users to initiate an electronic work order request.
- Allow authorized user to assign a priority level to each work order.
- Allow authorized user to modify the execution schedule of each work order.
- Include a work order approval procedure, allowing Maintenance staff to review, modify and authorize work order requests.
- Support the work permitting process (e.g. issuing work permit requests).
- Allow authorized users to enter feedback information after work completion, such as comments or time spent on each activity.

The Warehouse Management module of the CMMS maintains a master catalogue of all materials and spare parts stored in the Plant warehouse, accurately monitors the inventory of actual stocks, helps in easily and quickly locating each item, initiates the operations of material replenishment and provides statistics on each item usage.

The Warehouse Management module allows performing cross-checks between stock inventories and orders/reorders of similar material or spare parts in order to avoid unnecessary duplication or orders/reorders.

Following functionalities of real-time stock inventory management are available:

- Monitoring cost of each item according to different criteria, such as costs of last purchasing and average cost during any user configurable period / time interval.
- Continuous monitoring of stock inventories of materials and spare parts.
- Automatic generation of order/reorder requests whenever the stock of an item decreases below or approaches a minimum threshold.
- Automatic detection of the quantity to be ordered and calculation of the time to trigger the order/reorder request according to usage statistics, target maximum quantity to be stored, as well as expected time for replenishment.
- Automatic calculation of statistics on the usage of each item, such as quantity of pieces used per week, month, and year.

The Preventive Maintenance module of the CMMS is capable for automatically producing work orders for all maintenance operations to be executed at predefined time intervals or according to pre-set criteria.

The Preventive Maintenance module allows the following functions:

- Automatic generation of work orders according to different triggering criteria, such as schedule, frequency, elapsed time, running interval, etc.
- Arrange and combine several work orders together, in order to minimize unit/equipment downtime or take advantage of unplanned downtime.
- Retrieve and list all scheduled maintenance works to be done during any given time interval.
- Record and archive job plans for routine maintenance, along with relevant detailed work instructions, applicable procedures, estimated duration, required spare parts, tools and manpower resources (estimated man-hours and skills).

- Record and archive job procedures for repetitive maintenance activities, such as procedures for lubrication.

The Predictive Maintenance module of the CMMS is capable of automatically producing work orders for all maintenance operations to be executed upon receipt of triggering signals generated by internal logics or by other applications/systems.

The Predictive Maintenance module allows at least the following functions:

- Automatic generation of work orders on the basis of triggering signals received from self-diagnosis tools of smart transmitters/actuators or from performancelogics implemented in dedicated machine monitoring systems.
- Arrange and combine several work orders together with other scheduledroutine works, in order to minimize unit/equipment downtime or take advantage of unplanned downtime.
- Retrieve and display the variation curve of the parameters that are used fortriggering predictive maintenance actions during any user configurable period /time interval.
- Estimate the most probable date for a maintenance intervention based on thecurrent trend of the controlled parameters.
- Record and archive job plans related to predictive maintenance.

The Plant Turnaround module of the CMMS provides tools and information required for organizing and monitoring maintenance activities to be carried out during plant shut-down.

In addition to the functions provided by other CMMS modules that are designated to follow the turnaround activities, this module provides also the following specific functions:

- Record and archive job plans for periodic Plant turnarounds.
- Automatic generation of turnaround work orders on the basis of turnaround job plans.
- Aggregate data from different turnaround work orders, and provide real-time information and statistics about overall work progress, actual versus forecasted spent man-hours, actual versus estimated costs, etc.

The Inspection module of the CMMS provides tools and information required for organizing and monitoring inspection activities on specific critical equipment and lines, and provides the following functions:

- Record, archive and retrieve information regarding inspection points, inspection circuits, equipment to be inspected, inspection procedures, etc.
- Allow to combine multiple inspection test points to a given asset, with different priorities (high, normal and low).
- Record, archive and retrieve data collected during the inspection operations along with any relevant comment from Inspectors.
- Automatically issue recommendations on next inspection schedule according to logged inspection results.
- Automatically retrieve from other systems (DCS or RTDB) the actual service running time as well as operating conditions.
- Executes specific calculations aimed to check the status and integrity of a piece of equipment, and to estimate remaining operating life according to logged inspection results.
- Trend, correlate and predict data (in real-time), and automatically issue warning messages when exceptional or unusual conditions are detected.
- Whenever the results of the inspection require and an immediate analysis and action, automatically issue warning messages to maintenance personnel and trigger Predictive Maintenance work orders.

The CMMS system is equipped with a dedicated powerful reporting tool which is capable of generating a number of predefined reports on a fixed basis, on-demand or on an event basis.

CMMS reports provide the Maintenance Department with the necessary feedback information to identify areas of maintenance activities that may be improved and optimized.

Authorized users are allowed to request pre-formatted reports at any time by means of user-friendly interfaces (pull-down menus, selection lists and fill-in the blank fields), as well as configuring and customizing ad-hoc reports.

The reporting module supports embedding of electronic photos in the reports, and allows the transfer of all or part of the data contained in the report into standard Microsoft Excel or Word applications.

III. Conclusion

Uzbekistan Gas to Liquid plant is the step to the future where all production facilities will be digitalized and represented as informational models in analytical clouds. Implementation of intelligent IT-infrastructure in the conceptual design of this plant today will definitely bring huge benefits tomorrow. We do hope that highlighted IT-solutions will cause a genuine interest of IT and automation specialists worldwide.

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