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Application of MES System in Offshore Oil and Gas Field Production Management

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Abstract: In order to solve information island problem of offshore oil and gas field production-related information system, including repetitive reporting and input of data, data isolation of central control system, inadequate follow-up analysis and development to support oil and gas field production management, and so on. Therefore, the introduction of MES (Manufacturing Execution System) production execution system in the manufacturing industry and downstream production of offshore oil has become an inevitable choice. This system utilizes the real-time database combined with relational database to collect the scattered structured data, such as the production process real-time data, production management documents and statistical tables of offshore oil and gas production facilities. It establishes a unified data center platform for each operation area and production site, so as to centralize the related production management data at production sites. This system realizes many functions, including the production management support like production report generation as well as presentation and POB, equipment management support like PM optimization, remote configuration and monitoring of production operation, status trend analysis, and production event prediction. The implementation of MES system in offshore oil and gas field production management perfects the overall information system of China National Offshore Oil Corporation more and gradually enhances its comprehensive benefits.

Keywords: Production management, equipment management, process control, Manufacturing execution system.

1 Introduction

At present, China National Offshore Oil Corporation (formerly named as China National Offshore Oil Corporation) (abbreviation "CNOOC") has realized automatic process control at each production facilities. Some different processes adopt distributed control system (DCS) [Michaelides and Morgenstern (2007); Xiang, Huang, Chen et al. (2013)] or programmable logic controller (PLC) [Valencia-Palomo and Rossiter (2011)] for the control. Meanwhile, CNOOC has successfully implemented the related information

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system of Enterprise Resource Planning (ERP) [Ragowsky and Somers (2002)], including MAXIMO (enterprise asset maintenance management system of IBM) [Guangming (2006)], System Applications and Products (SAP) (comprehensive analysis and decision support platform for development and production), Production Intelligence Management System (PIMS) [Huang, Hu, Li et al. (2017)] and so on. ERP system and oil and gas field automatic control system have developed to a relatively mature level, but they have isolated islands of information, which means that their data cannot be shared and used. ERP system serves for enterprise managers and does not provide direct support for the management process of production facilities. The functions of oil and gas field automatic control system mainly lie in the production process control of oil and gas fields, as well as the monitoring of field equipment and process parameters. It can satisfy the requirements of oil and gas production control and status alarm by field producers, but it cannot share data with management information system. At the same time, the production control network and the enterprise office network are physically isolated, and the control system data cannot be transmitted and shared. As a result, the enterprise management information system lacks effective real-time information support and the management users cannot see the scene of production situation quickly. Problems can be caused on the data due to faulty sensing processes and/or lost links, etc. In order to ensure the quality of retrieved load data, different solutions have been presented, but suffered from low recognition rates and high complexity [Liu and Liu (2018)], data in the field control link cannot be fully analyzed and applied, while analysis and decisions cannot be made quickly and effectively. In addition, a lot of data of production management comes from the production automation control system. It needs to be manually transcribed and reported because information cannot be shared.

In the field production management, field flowmeters and electric meters in distribution rooms are scattered on the spot, except for DCS display data. Every day, the manual copying and transmission of data is cumbersome, and it is easy to cause data deviation in the process of transmission. Different on-site reports still rely on manual statistics, which are heavy workload, backward means, occupying a large amount of working time, unclear job responsibilities, and difficult to guarantee accuracy. At the same time, business data is stored dispersedly, closed, and non-standard. The format is not uniform and data capture is difficult. Decentralized EXCEL reports need a lot of manual operation, which is difficult for maintenance and easy to make mistakes. Decision analysis report often needed to obtain data from multiple departments and to manually turn over paper documents, mails and EXCEL tables. Managers are busy integrating reports most of the time, while data lacks timeliness and intuition. Key data such as production and equipment cannot provide centralized online query, which is not convenient for production process analysis and management.

Therefore, in order to solve the above problems, Shenzhen Branch of CNOOC (hereinafter referred to as Shenzhen Branch) introduced MES production execution system, which has been well applied in manufacturing and downstream production of CNOOC. The system is named as Manufacturing Execution System (MES).

MES [Wang, Zhang and Chen (2010)] is originated in manufacturing industry and widely used in product manufacturing enterprises. MES takes the idea of real-time collaboration

[Kovachev, Nicolaescu and Klamma (2014)] as the leading factor and takes the execution of production plan and the dynamic scheduling of workshop as the core. It integrates the advanced management concepts, such as lean production concepts and methods, restraint theory, enterprise resource optimization theory, supply chain management, external cooperation management, human resources management, business management and so on. Driven by the growing security demands of data outsourcing applications, sensitive data have to be encrypted before outsourcing. Therefore, how to properly encrypt data in a way that the encrypted and remotely stored data can still be queried has become a challenging issue. Searchable encryption scheme is proposed to allow users to search over encrypted data. However, most searchable encryption schemes do not consider search result diversification, resulting in information redundancy [Liu, Peng and Wang (2018)]. The informationization integrated management application system for enterprise production and manufacturing [Qu, Zhu, Wang et al. (2018)] is built with fully absorbing the experience, lessons and research results of enterprise information construction in the past decades at home and abroad, especially in discrete manufacturing enterprises. SMES [Yang (2011)] has been developed on the basis of MES, which mainly serves for small and medium enterprises. MES focuses on enterprise users who need manufacturing information construction. It is one of the core foundations for manufacturing enterprises to achieve comprehensive and advanced management. At present, it is applied maturely in downstream industries of CNOOC.

MES mainly introduces the real-time database of MES and its best practice in enterprise data analysis. By using the real-time data application function, the system combines the production process control and enterprise management information system. This system which runs through the whole production process and takes the data support of production and equipment management as the function center.

It extracts data from field control system and provides timely and reliable production data for management users. It summarizes and analyses the data, helps users make corresponding production decisions, generates various production-related reports which enables related managers of facilities and operating areas to know the real time production conditions online, and make timely decision and deal with different kinds of problems in the production. Finally, it realized the centralized and unified management of production real-time data and production management data, as well as information sharing. It provides production managers with data support of daily production management, equipment management, production optimization and production decision, liberating production managers at all levels from tedious and repetitive business work. It lays the foundation for realizing the real digitalization, visualization and automation of intelligent oilfield applications.

2 System design

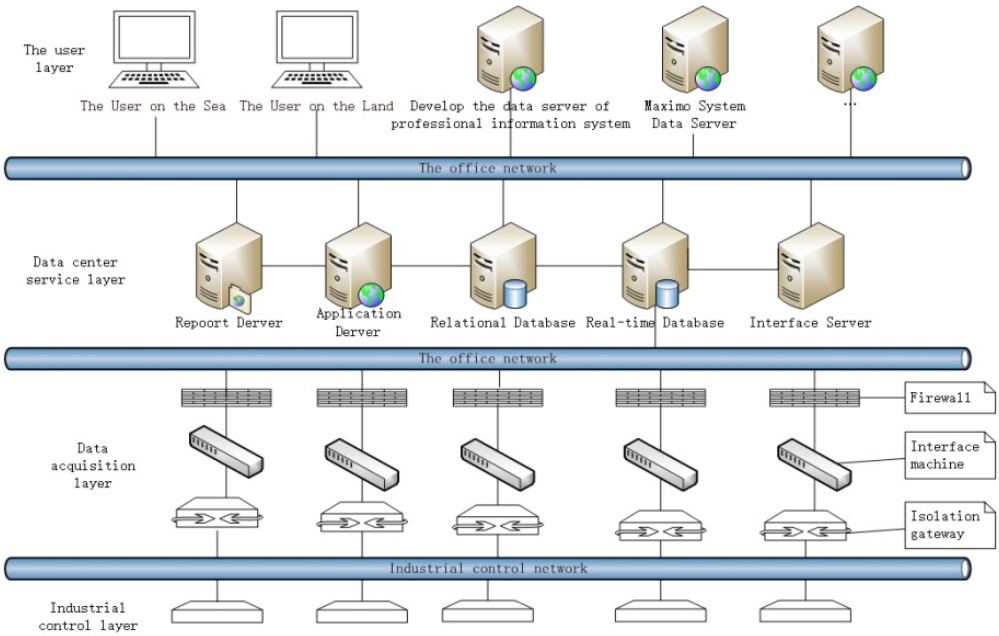

Figure 1: System design framework

2.1 Data collection layer

The central control system of the offshore platform collects a large number of production data from the controller. The data server of the information platform reads the data in the central control system through the open OPC interface, connects the production control network with the enterprise office network, and transmits the data to the real-time database on land through the network for storage. It is persistent to provide data source for decisions made by production management and data analysis layer. It also solves the problem of information island.

2.2 Business application layer

Business application service uses Asp.net 4.0 technology to realize Web [Springer (2009)] access service, and is built on real-time historical database platform and MS SQL Server. With the development of abundant application function modules, the daily reports of production, single well tests, working daily reports and chemical reagent reports are managed systematically. Data are extracted from the field control system with summary, analysis and calculation. It supports automatic generation of reports, reduce manual errors of on-spot report production, and staff workload. And it enables facility managers and managers of Shenzhen Branch to get real-time online information about production status through the network.

2.3 Business application layer

Through WCF service [Mackey (2010)], data interaction with external systems such as MAXIMO and production real-time system is realized. It provides real-time measurement data or statistical summary data for external systems, and realizes PM application based on real-time data. Therefore, MAXIMO is equipped with status maintenance and preventive maintenance based on real-time data of equipment, and supports the automatic generation of preventive maintenance reports. Meanwhile, the automatic data acquisition of many modules is improved, including MAXIMO equipment reading, equipment condition monitoring points, equipment fault code and downtime reports.

3 System functions

3.1 Data center

There are too many professional systems in oil field, operation area and branch company, where unified production and equipment data support platform is lacked. It needs the integrate, integrate and integrate business system management to solve the difficulties in report statistics and decision analysis. Based on MES real-time database and relational database, a unified data center platform for each operation area and production site is established to centralize production data on site. It has the ability to automatically acquire and store real-time on-site data in all aspects, which means that it can acquire and store relevant production and equipment data from DCS, PLC, SCADA, and intelligent instruments. Therefore, it relieves the complexity of daily manual copying and transmission of data, and liberates the human productivity. At the same time, it supplements the relevant data by manual input or import, so as to supplement the real-time data and improve the integrity of production data. It unifies the data sources on spot and standardizes the on-site production management. Meanwhile, it provides data support for production optimization and decisions, and supports the establishment of operation area portal centered on on-site key data. It enables users on land or at sea to have centralized access to data which they care about. It is clear and intuitive, and eliminates the tedious problem of browsing mail or documents. to unify data management and display, and to improve management efficiency. The unified data management and display enhance management efficiency.

3.2 Production management support

The automatic acquisition of real-time data on spot is realized. It supports the information management of production daily reports, single well test, production allocation tables, export comparison tables, cargo tank tables of ship system, working daily reports and so on through the system. Data are extracted from the field control system with summary, analysis and calculation. It supports automatic generation of reports, reduce manual errors of on-spot report production, and staff workload. It makes the responsibilities of each position clear, and enables facility managers and managers of Shenzhen Branch to get real-time online information about production status through the network. It avoids the user's manual work of filling in and submitting the reports, and unifies the data sources of the reports, truly connecting the office with the production site.

At the same time, on-site staff, POB, operation, flight and other production auxiliary

management information is also unified through the system for management, improving the field management function of the system in all respects. It solves the difficult problems of on-site management, standardize the management process, optimize the management mode, reduce internal friction of communication, pursue the ideal management results, realize the standardization of management, and institutionalize the process. It makes the daily management and other information of different departments, sites and land have the timely, efficient, orderly, and controllable communication and solution which are shared in the whole process. As a result, it can improve the office efficiency and management application level in all respects.

In addition, the real-time data of MES system is opened to third-party systems such as intelligent dynamic of production wells by publishing Web Service interface services on system terminal of MES. It enables upper systems such as intelligent dynamic management of production wells to obtain real-time production status data together through MES system platform, and to display and analyze the data accordingly.

3.3 Remote simulation and monitoring

The visualization of production process is realized. It collects real-time operation status and operation parameters from the on-spot central control system, and transmits them to the monitoring terminal to be decomposed into the report forms, charts or visual interface forms required by users. Meanwhile, according to the actual needs, the collected data go through post-processing, like centralized storage, process and output. And the real-time data is visually monitored according to the set interface and alarm conditions, providing relevant real-time state information. The online tracking function can produce historical records.

Aiming at the key equipment and safety equipment which are very concerned by the land, it can collect the relevant state parameters and real-time operation status, and use IFIX software to carry out remote simulation configuration at the land. The managers of Shenzhen Branch can intuitively get the real-time status of key equipment on site, providing support for safety emergency and production command management.

3.4 Trend analysis and forecast

By collecting real-time data of production site and basic data of process management, a comprehensive analysis platform is established with key data, such as output comparison, equipment status and process. It realizes multi-dimensional analysis of business data and provides managers with flexible and multi-directional statistical aggregation, analysis and aggregation functions.

With analysis and modeling tools, business topics are planned and predicted, and development trends are analyzed, which provide a strong basis for scientific decisions.

4 The experimental results

4.1 Sharing on-spot data

A data center supporting on-site production and equipment management has been established. It realizes centralized and unified management of production real-time data and production management data. It makes full use of database technology, modern

network technology and computer technology to achieve information sharing, truly connecting the office and production site.

4.2 Simplifying reports submission

In the past, all kinds of data were collected regularly by on-spot staff with manual input, which not only had a heavy workload, but also lacked real-time. At present, the reports can be generated automatically by the system with high speed and accuracy, which frees the managers of production equipment at all levels from the tedious and repetitive business work and eliminates the work of filling in and submitting the reports manually by users. It unifies the data sources of the reports and provides production equipment managers with data support about daily management and optimization.

4.3 Assisting production decisions

The comprehensive dynamic visualization is realized, including traceability and historical data storage of production data and equipment operation historical situation, real-time condition monitoring and trend analysis of equipment in production process, and so on. Accurate and real-time on-site data acquisition is the basis for managers to get the timely dynamics of production site, have rapid response to the actual production process, and make trend analysis and decisions about historical data.

4.4 Standardizing management process

Through systematic information management, it standardizes the management process, eliminates manual errors in the process of production and transmission, and pursues ideal management results. In addition, optimizes management mode, reduces internal friction of communication, and realizes management standardization and process institutionalization.

4.5 Improving execution efficiency

The application of this system, it reduces the workflow links, promotes the office efficiency of users. It not only makes personnel communication real-time and quick, but also transmit tasks efficiently and clearly, understanding of the progress of tasks and work in time.

5 Conclusion

With the application of MES in offshore oil and gas fields, real-time data extracted from production field control system are integrated with bottom production automation system and upper ERP. It realizes the business application about gathering, transmission, storage, process, summary, analysis and publish and management of on-spot production information. It supports the optimization of production management on site, and meets the needs of on-spot daily production operation, production management, production monitoring and data display. At the same time, it establishes the data base for the managers to realize the functions of comprehensive display about production data, shutdown management, oil extraction operation, equipment management, maintenance plan and comprehensive query. It also offers effective supplement and extension to meet

the needs of real-time production data by the upper system. It makes the whole information system of CNOOC more perfect, and gradually reflects the comprehensive benefit and important role of MES in offshore oil and gas field production management.

References

Guangming, Y. U. (2006): Maximo software applied to management of work order and operation order in power plants. *Guangdong Electric Power*, vol. 19, no. 6, pp. 60-63.

Huang, S.; Hu, N.; Li, G.; Hou, J.; Pan, T. (2017): The production management system of mining group based on business intelligence. *Second International Conference on Information Systems Engineering*.

Kovachev, D.; Nicolaescu, P.; Klamma, R. (2014): Mobile real-time collaboration for semantic multimedia. *Mobile Networks and Applications*, vol. 19, no. 5, pp. 635-648.

Liu, X. D.; Liu, Q. A. (2018): A Dual-spline approach to load error repair in a HEMS sensor network. *Computers, Materials & Continua*, vol. 57, no. 2, pp. 179-194.

Liu, Y. L.; Peng, H.; Wang, J. (2018): Verifiable diversity ranking search over encrypted outsourced data. *Computers, Materials & Continua*, vol. 55, no. 1, pp. 37-57.

Mackey, A. (2010): Windows communication foundation. *Expert Asp Net*, vol. 38, no. C1, pp. 159-173.

Michaelides, A.; Morgenstern, K. (2007): Real-time and non-real-time data network in distributed control system. *Process Automation Instrumentation*, vol. 6, no. 8, pp. 597-601.

Qu, Z. G.; Zhu, T. C.; Wang, J. W.; Wang, X. J. (2018): A novel quantum stegonagraphy based on brown states. *Computers, Materials & Continua*, vol. 56, no. 1, pp. 47-59.

Ragowsky, A.; Somers, T. M. (2002): Enterprise resource planning. *Journal of Management Information Systems*, vol. 19, no. 1, pp. 11-15.

Springer, U. S. (2009): Web services business process execution language. *Medicina*, vol. 44, no. 1, pp. 64-71.

Valencia-Palomo, G.; Rossiter, J. A. (2011): Programmable logic controller implementation of an auto-tuned predictive control based on minimal plant information. *ISA Transactions*, vol. 50, no. 1, pp. 92-100.

Wang, H. Y.; Zhang, Q. L.; Chen, Y. H. (2010): Manufacturing execution system and its application in petrochemical enterprise. *Computers and Applied Chemistry Journal*, vol. 27, no. 1, pp. 113-118.

Xiang, G.; Huang, D.; Chen, Y.; Jin, W. (2013): The design of a distributed control system based on CAN bus. *IEEE International Conference on Mechatronics & Automation*.

Yang, T. (2011): The deepening application of SMES in Anqing petrochemical. *China Information Times Journal*, vol. 183, no. 7, pp. 108-111.