WRM：Integrated Value Management of Oil & Gas Exploration and Production

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Abstract—**This paper explores the management ideas/tools underlying Well and Reservoir Management (WRM) for Oil & Gas exploration and production. WRM is an integrated management which covers the whole chain of Oil & Gas exploration and production from subsurface Reservoir Management to Well, surface facilities, and export system. WRM aims to maximizing the life-cycle value (in ultimate recovery or financial measures) of the whole production system. From the perspective of management theory, the success of WRM lies in the integration of management ideas/tools of Lean production, Total Quality Management (TQM), and Process-based organizational structure.**

Keywords-Well and Reservoir Management (WRM); integrated value management; value loop; Lean production;Total Quality Management(TQM); Process-based organizational structure

I. INTRODUCTION

The production and operation of oil companies is constrained by various factors, such as technology, economic considerations, environmental regulations, resource stock, and strategy of a country. The technology-centric production management is not supportive enough for the oil companies' sustainable development. Integrated management is increasingly necessary for managing oil companies under the resource constraint, and is also required by the resource and energy development of a country. The production management of oil companies has improved from focusing on reservoir management to emphasizing the integration of undersurface reservoir, well and surface facilities. WRM (shorthand for Well and Reservoir Management) has become the prevailing management system for large oil companies domestic and abroad. Oil companies as BP and Shell group have successfully implemented WRM in many oil exploration and production projects, and made great economic performance. The practice of Petroleum Development Oman (PDO) showed that continuous WRM process played an important role in each phase of the oil field's life cycle. WRM is one of the processes for controlling oil and gas production. PDO made significant achievements by implementing WRM: a) achieving higher and continuous production growth than expected; b) significantly restraining the decrease in overall production. Oil production with compression constraint has decreased dramatically to a very low level; c) a large amount of capital expense is saved by WRM effort (E. Ali, F.E. Bergren, J.S. Saluja, and I.S. Sinani,2005). Shell Salym Development B.V. (SSD) and Russian Evikhon joint venture Salym Petroleum Development N.V. (SPD) achieved remarkable result by using Oil Field Management (OFM, based on the value loop of WRM) in managing oil production. Long-run reservoir management improved oil recovery continuously. Mid-term Production System Optimization (PSO) increased the initial production and decreased water production whilst not decreasing oil production (Andrew Mabian, Yakov Volokitin, Natalia Beliakova, et.al, 2010).

This paper, from the time dimension of value management and the production elements of value loop of WRM, is designed to explore the main idea of WRM theoretically from the perspective of integrated management based on the success of WRM in practice. The analysis helps demonstrate the reasons for success of WRM in practice, and provides useful references for oil companies in managing production.

II. WRM AND ITS VALUE MANAGEMENT

A. *What is WRM*

WRM is an integrated management system for oil exploration and production covering the overall chain of reservoir, well, and surface facilities. Integrated well and reservoir management (WRM) has evolved from the early method of isolated reservoirs and wells reviews carried out by the petroleum engineers (mostly involving only the reservoir engineers and production technologists) to an integrated approach involving the participation of production geologists, petrophysicists, well completion and intervention engineers, process and facilities engineers, production programmers and production operations engineers(Ayoola Olakunle Thomas, Uruh Oke-oghene, Odizuru-Abangwu Ijeoma, et.al, 2010).WRM is the combination of management idea and tools with reservoir engineering and technology.

WRM is defined as: WRM maximizes the life cycle value of the production system of oil exploration and production consisting of the whole range of assets from reservoir, well, and the surface facilities to export system by: a) effective management of data; b) building disciplinary models and overall production model; c) predicting accurately the long-run, mid-term, and short-term production, reserves, and costs; d) forming improvement alternatives and plans by identifying value drivers for improvement; e) implementing the chosen improvement alternatives and plans.

WRM has the objective to safeguard the recovery of the developed reserves, whilst optimizing the short-term production level within the provided budgets(M. Habsi, A. Ikwumonu, K. Khabouri, K. Rawnsley, I. Ismaili, R. Yazidi, and PH. Putra, 2008). The scope of WRM includes well integrity, reservoir and well surveillance, and performance restoration and optimization.

B. Value Management of WRM

WRM is closed-loop value management over the life cycle of an oil company, which is a combination of model-based optimization and data assimilation. The practice of WRM is not a project with a linear start and an end period, but is rather an iterative process where on a continuous basis the effectiveness of activities is improved by comparing the actual performance with predictions (Figure.1). The life cycle value of an oil company is maximized by finishing the value loop of WRM where data is acquired from physical assets (reservoir, wells, and surface facilities) and subsequently incorporated into models that drive the optimization of these same physical assets. The value loop has different cycling times ranging from seconds to decades (Figure.2). Traditionally, the shortest value loop is called Real Time Optimization (RTO) with a time span measured in seconds, minutes and hours, followed by WRM with a time span measured in weeks, months or years, and finally Hydrocarbon Development Planning (HDP) with a time span measured in years, if not decades.

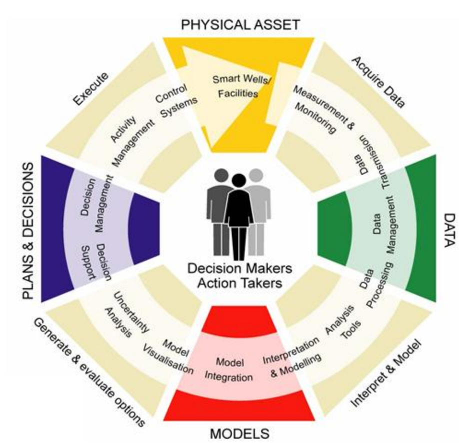

Figure 1. Value Loop of WRM (Andrew Mabian, Yakov Volokitin, Natalia Beliakova, et.al, 2010)

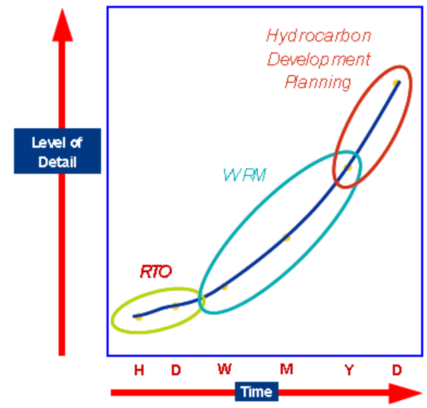

Figure 2. Cycling Time of Value Loop(Andrew Mabian, Yakov Volokitin, Natalia Beliakova, et.al, 2010)

Within the value loop of WRM, long-term reservoir management and Production System Optimization (PSO) is based on the yearly and monthly time scale respectively.

*1) Long-term reservoir management:*The high level objectives of Reservoir Management are to safely maximize production and ultimate recovery whilst containing operating costs within provided budgets. As mentioned above, WRM is a closed-loop value management. The closed-loop long-term reservoir management is to maximize reservoir performance, in terms of recovery or financial measures, over the life of the reservoir in a near-continuous reservoir management rather than a traditional periodic process(J.D. Jansen, S.D. Douma, D.R. Brouwer, P.M.J. Van den Hof, O.H. Bosgra, and A.W. Heemink, 2009). The underlying hypothesis is that it will be possible to significantly increase life-cycle value by changing reservoir management from a batch-type to a near-continuous model-based controlled activity. Data assimilation algorithms determine the optimal solution by comparing predicted output from system models with measured output from sensors by the process of data assimilation, which provides the basis for modeling or continuous improvement of systems models and ultimate maximization of the whole production assets by coordinating reservoir with well and facilities (Figure 3).

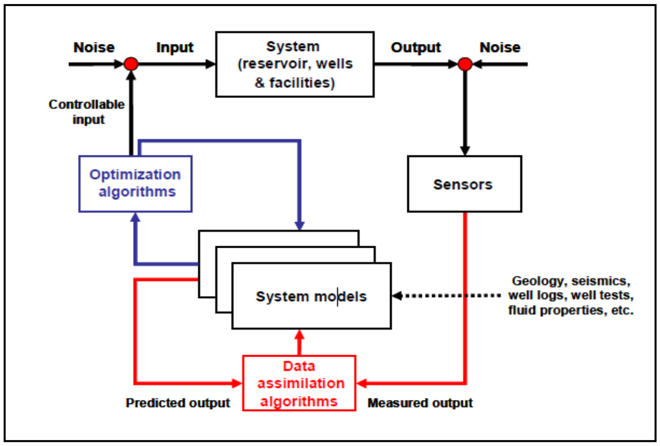

Figure 3. Key elements of the closed-loop reservoir management process(J.D. Jansen, S.D. Douma, D.R. Brouwer, P.M.J. Van den Hof, O.H. Bosgra, and A.W. Heemink, 2009)

2) Mid-term Well and Facilities Management (Production System Optimization, PSO): Production System Optimization (PSO) is the component of WRM that identifies opportunities to maximize the long-term value of the production system. This is achieved by combining regular surveillance with a clear understanding of elements of the production system (well and facilities) and how they perform in an integrated manner. PSO involves primarily Surveillance, Calibration and Optimization embedded in the lower part of the loop (Figure 4). Implementing PSO opportunities results in changes to existing production system components and typically occurs within days to months, whilst honoring operating constraints including those that will maximize life cycle value.

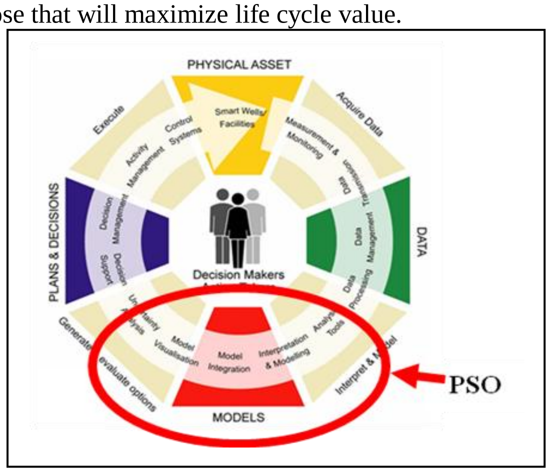

Figure 4. Value Loop and PSO(Andrew Mabian, Yakov Volokitin, Natalia Beliakova, et.al, 2010)

In WRM context, PSO starts with Data (Data Management, Data Acquisition) and ends with opportunities going into the Opportunity Register, which in turn feeds actions into the Integrated Asset Planning process along with other items for implementation. The optimization of a production system easily breaks down into the steps of surveillance, calibration and optimization. Surveillance tells whether the behavior of the system is as expected or not. Calibration is the process of improving system models to match reality, if it does not do so adequately. Optimization is the process of improving the performance of the system to generate value.

III. Management Ideas/Tools of WRM

WRM integrates the reservoir engineering/technology and different management theories into one system. WRM is designed in terms of the idea of lean production, total quality management, theory of constraint, and liberation management.

A. Lean Production

WRM is originated primarily from the Toyota production system (Lean production) from the perspective of management theory. WRM is based on the Lean principles of waste elimination, value stream mapping, continuous flow, pull and continuous improvement (lean manufacturing, Wikipedia, 2009). Exception Based Surveillance (EBS) of WRM is one of the processes resulted from the Lean concept. The Lean concept that is added to the WRM mandates that a set of standard operating procedures (SOPs) follow each exception. EBS helps identify and execute exceptions against SOPs. Work that is performed is role based and people execute against the highest value work at each step. Those steps are followed and only when it is noted and reevaluated through a Kaizen event is the process changed or by SOP owners(Jorge Yero and Thomas A. Moroney, 2010).

Another Lean principle that added to EBS is to make the information visible. Andon boards, usually a Central Control Room (CCR) in practice, give supervisors the ability to load balance work no matter where the individual is originally assigned. "Signals" are also monitored for improvement opportunities when the frequency of the event is significantly higher than other comparable events. Finally, signals follow an assigned workflow so that once assigned work is completed by the signal recipient, the signal will be passed on to a person in the appropriate role for the next level of analysis.

In addition, workflows help the assets by capturing their workers knowledge into standard business practices. Workflows can capture the knowledge of these most valuable engineers for storage and sharing within the organization. This will enable newer workers to accomplish the same work with less learned knowledge, and possibly come out with even better work processes and even better ways of doing things, resulting in continuous improvement for the company, leading to improved production operations.

B. Total Quality Management

Total Quality Management (TQM) is applied throughout the value loop of WRM. Multidisciplinary team is a good example of TQM for WRM in practice. People from reservoir engineering, well service, operation, production technology, etc. cooperate in almost each improvement decision through all types of meetings.

Well and Reservoir Surveillance (WRS) is a foundation for WRM. WRM requires that detailed surveillance plan be made. Abnormal variance is judged by comparing performance data of well and reservoir with operation envelope made in WRM plan, and Root Cause Analysis (RCA) is done by all disciplinary teams. After finding out the reasons for abnormal variances, improvement plan and decisions are made, and then related envelopes are calibrated, and finally processes and models are optimized.

In designing the processes of WRM, the Lean six sigma process of define-measure- analyze-improve- control (DMAIC II) is transplanted to the system.

C. Process-based Organizational Structure

Collaborative Work Environments have been implemented by several major oil companies, to support the use of technology in Smart Oil Fields.

What type of organizational structure is most appropriate depends on the organization's objectives (e.g. Collier, 1992). First, oil companies are applying Well & Reservoir Management (WRM) to get addition production and recovery. The value of WRM for oil companies is increasing production capacity and ultimate recovery (Van Zandvoord et al., 2009). Second, oil companies are trying to reduce the time-to-market (e.g. speed). From an organizational perspective, increased efficiency and effectiveness are required, to stay ahead of competition. Oil companies find their realization of increased efficiency and effectiveness by installing Collaborative Work Environments. Oil companies applying WRM normally change the organizational structure into process-based one. A certain asset of Shell group established three-hierarchy structure: WRM customers, WRM team, and WRM steering team. Each hierarchy consists of people from different disciplines.

IV. SUMMARY

Integrated management is one of the main features of WRM and also an important reason for the success of WRM in practice. WRM integrates Lean principle in manufacturing and TQM into one management system appropriate for applying in the upstream and downstream of oil exploration and production. WRM attempts to link seamlessly all the point of the whole chain from exploration to export to end users. WRM aims to make full use of the capacity of the overall production system by eliminating the constraints in terms of Theory of Constraint (TOC) through evaluating the subsurface resources, surface facilities, and export system. The life-cycle value of the overall assets is maximized by executing the activities of collecting data-establishing/calibrating modes-decision making and planning. However, change in the organizational structure is necessary for successful WRM in practice, especially real cross-discipline team, which is the very problem many Chinese oil companies need to address.

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