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Conceptualization of smart solutions in oil and gas industry

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Abstract

Technological solutions called "smart wells" and "smart fields" have been applied in petroleum industry for nearly two decades. They aim to improve the knowledge of petroleum production processes, and thereby improve the efficiency of operations. Researchers and companies in pursuit of their goals tend to use one-sided implications and numerous synonyms when describing the substance of the term, which leads to an occasional confusion. In order to study the concept of smart field from a general perspective, a literature review has been conducted, and main characteristic attributes of such solutions have been revealed. Selected marketed products offered by engineering companies have been analyzed as examples of the technology implementation. A definition has been proposed along with its practical implications. Additionally, an attempt has been made to place these solutions in a broad scientific context of intelligence and sustainability in contemporary business processes.

1. Introduction

Information technology (IT) is one of the major driving forces in modern businesses practices. It expands the industry boundaries and even reshapes the industries[19]. Application of IT is essential for oil and gas industry. The efficiency of expensive and dangerous operations largely depends on employment of IT in the form of process automation and control tools. Over the last several decades, the complexity of petroleum production operations increased. By the end of the 20th century, many large conventional hydrocarbon reserves have depleted, and production has shifted to offshore locations and nonconventional petroleum reserves[4,17]. Costly operations, inconvenience of frequent interventions for remote locations and subsea wells, harsh weather conditions and many other technological, economic and safety issues require significant scientific intensity to adapt the known technologies to the non-conventional environments of hydrocarbons recovery. In 1990s, a demand for innovative process control tools ensuring economic efficiency of producing oil and gas in these challenging circumstances[17] emerged in the industry.

The accumulated research in the oil and gas domain provided abundant capabilities to improve production management through applying the mathematical modeling in order to achieve necessary economic goals. New

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machinery and instrumentation was also engineered for long uninterrupted operations in complicated conditions[9]. The pilot project of a solution named "smart well" was implemented in 1997 on the Snorre Field in the North Sea by a Norwegian company Saga Petroleum (presently a subdivision of Statoil). Since then, hundreds of smart well systems have been put into operation around the world[8,24]. The scope of the term later evolved to "smart field", which implies a larger scale of integration. Oil bearing formations, wells, gathering and processing facilities become addressed as consolidated hydrodynamic systems. In terms of decision making, the lifecycle viewpoint is now applied: every decision made should be optimal with regards to the goals set for the entire system lifecycle.

Several terms are presently used in business and research for addressing this approach to development and operations in petroleum industry. In the literature, the terms "smart" and "intelligent" fields are widely used. Among other popular synonyms "i-Fields", "digital oilfields", "fields of the future" can be named. In addition, several broader terms, e.g., "integrated operations", "intelligent operations" and "intelligent energy", are often used to describe similar solutions.

The smart solutions have by now gained fair recognition in both industry and academia. However, there is still occasional confusion around this concept. On the one hand, engineering companies in pursuit of marketing success for the solutions they are offering, tend to use an ample variety of terms to name similar products and attributes. On the other hand, academic articles tend to focus on certain particular aspects of the complex concept, e.g., some authors address advances in automation and measurements, others emphasize advanced control techniques, still others focus on process simulations and predictive modeling. Thus, the accumulated theoretical and practical research results require analysis and synthesis to maintain the entirety of the perspective. The purpose of this research is to study the concept of smart field from the most general perspective. The main research points are to identify what these smart solutions actually are, what basic attributes they have and what technologies constitute to this notion. The obvious value of a smart field definition is contribution to the glossary of petroleum engineers and managers. More importantly, however, a proper definition would help identify the achievable benefits of such solutions. The definition would facilitate the system thinking of energy industry managers, becoming the first step in helping the managers to regard the decision of deploying or not deploying a smart field as a strategy of organizing the upstream sector of petroleum industry supply chain, rather than a decision on purchasing certain advanced instrumentation.

The methodology of this research involves literature review on the topic, carried out up to the present moment. This allows to generalize the knowledge about smart solutions in the upstream petroleum sector and to distinguish their characteristic features. In addition, selected solutions which became trademarks of a number of well established engineering companies are reviewed. Their main attributes are summarized in a concept matrix. Finally, plausible views on the philosophy of contemporary management science and the role of systems intelligence in it, are presented. This aims to account for smart technological solutions beyond petroleum industry, and therefore, the perspective of organizing the production activities in the context of logistics and supply chain management is contemplated.

2. Overview of smart solutions in the upstream petroleum sector

2.1. Smart solutions in the literature

The literature review presented below is largely based on the ideas of Webster and Watson[26]. The search of relevant literature has been conducted over the scope of papers published in academic journals and conference proceedings distributed in electronic journals and available in the following databases: OnePetro, ScienceDirect, Springer Link, Emerald Insight and ProQuest.

Textbooks, dissertations and unpublished research have been disregarded in the considered pool of literature. With this the author aims to reflect the research tendencies in the field that is relatively young and rapidly developing. The overview scope is limited to English language only. There is, of course, a considerable amount of research in courtiers like Brazil, Norway, Russia, Saudi Arabia and others in the respective native languages, however the author assumes that the adequate amount of academic and practical results is presented in English language on numerous conferences, symposiums and seminars, especially those organized by the Society of Petroleum Engineers.

The temporal scope for the search includes the last two decades, given that the history of the smart solutions dates back to 1997[13,17]. The search was run for the relevant words and phrases in the titles, abstracts, and keyword lists of the papers in the aforementioned databases. The search operands included: "smart well", "intelligent well", "smart field",