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COMMENTS

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Smart oilfield development and transition of petroleum-based cities

Petroleum-based cities, whose economy and development mainly rely on natural petroleum exploitation, are facing severe economic, social, and environmental problems at present (Tan et al., 2016). The industrial structure of these cities is a relatively traditional industrial pattern, which is a petroleum-based and petroleum-intensive economy with comparatively low technology and efficiency levels (Dong et al., 2007). These cities have undertaken enormous stress of slow development in the rapidly developing society for which their situations must be changed.

Four reasons can explain the requirement of petroleum-based cities for transitions. First, oil and gas recovery has stepped into the late stage. Given that resources are nearly extinct, the recovery degrees and monthly total (comprehensive) water cut of the major old sub-oilfields of Daqing oilfield are 92% and 94.7%, respectively. However, the remaining oil is sparsely distributed, whereas the quality of newly discovered peripheral oilfield is declining. Second, petroleum-based economies lack driving forces. On the one hand, the economy excessively relies on hydrocarbon recovery. Triggered by the diving of global oil price in July 2014, a decline was observed in the GDP of Daqing; that is, only 261 billion CNY was generated in 2016, and a reduction by 40% in comparison with that in 2013. On the other hand, difficulties are encountered in maintaining beneficial oil and gas production considering the combined effects of increasing oil and gas recovery costs and low oil prices. Third, contradiction is observed in ground and underground space utilization between oilfield facilities and city development. Fourth, oilfield development imposes tremendous pressure on the environment of petroleum-based cities. Given that the location of stations and wells of the oilfield cannot avoid residential areas, the noise created by mechanical machineries, pipelines, and production facilities and the waste gas, water, and oil discharged during the operation may lead to severe pollution to the acoustic environment, atmosphere, underground water, and soil of residential areas. Moreover, petroleum-based cities require transformation and promotion.

In China, most metropolises have entered the range of smart cities, and petroleum-based cities are comparatively backward. These metropolises have great economic and environmental potentials and must present favorable living conditions in the energy field with depletion stage. Petroleum-based cities transitioning into smart cities are inevitable under the trend of smart city development. However, oil exploitation based on the oilfield as the primary service of petroleum-based cities drives economic development. Therefore, smart oilfield development is the key point of the transition of petroleum-based cities.

The concept of smart oilfield (Al-Kadem et al., 2018; Neri, 2018) evolves from the idea of digital oilfield (Sankaran et al., 2009; Saputelli et al., 2013). The core of digital oilfield is digitalization and networking, which emphasizes data collection. By contrast, smart oilfield introduces artificial and human intelligence, thus highlighting their integration and concentrating on data mining, knowledge sharing, intelligent management, and scientific decision-making.

Smart oilfield development, which is a complex, interdisciplinary, and systematic engineering, penetrates through the entire lifecycle of oil and gas field transition. To handle the collaboration between information technology application and oil and gas technologies, between the old and new oil and gas technologies, and between technical and management innovation, applying the engineering management mode of “continual integration”

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(Liu and Wang, 2017) is further extended on the basis of "long-acting, integral, and collaborative". That is, the spiral synchronized development of technical and management innovation, driven by developing target-dependent technical and process-dependent management innovation (Al-Kadem et al., 2018). The target and path of smart oilfield development have been proposed, and their application in the demonstration area of high-efficiency production capacity development (Sonne et al., 2018) based on large-scale cluster wells in Jilin oilfield has achieved considerable positive results; these results can provide a reference for future smart oilfield development. The targets of smart oilfield development are concluded as being "intelligent, efficient, green, and harmonious". Being intelligent refers to fully recognizing an oilfield status and intelligently adjusting and controlling reservoir management. Being efficient emphasizes high resource utilization efficiency and high profits in resource exploitation. Being green requires that the recovery process must be low-carbon emitting, environment-friendly, and safe. Being harmonious represents city development with coordinated resource consumption. The path for building a smart oilfield is conduced to becoming "digital, intelligent, intensive, and environment-friendly".

(1) Digital oilfield development. Digitalization is the basis of a smart oilfield. The application of advanced Internet of things, big data, and artificial intelligence technologies must be expanded. Moreover, fusing innovation between information and oil and gas disciplines must be stimulated. A sensor network that covers the oilfield must be built to capture real-time oilfield dynamic production information.

(2) Intelligent reservoir management. After fully recognizing the oilfield status, intelligent reservoir management technologies (Fig. 1), including reservoir dynamics simulation, reservoir analysis, zonal water injection, and automatic production optimization, must be developed. The dynamic simulation of the reservoir characteristics, automated oil and gas recovery operation and control, automatic production prediction, and continuous optimization of reservoir management must be conducted. Therefore, assistance is provided in decision-making, and the proficiency of the oil reservoir exploitation management is improved.

(3) Intensive production and concentrated organization. An intensive well construction mode must be extensively promoted. In this concept, oil wells are concentrated on several large platforms to reduce the footprint of an oilfield, rather than allowing these oil wells to be sparsely distributed like before. Therefore, the integration of geology and engineering must be strengthened. In addition, factory-like drilling and grouped large-scale hydraulic fracturing must be implemented, and advanced engineering technologies must be introduced. Moreover, the production management process of the oilfield must be optimized and flattened to improve the efficiency and stimulate the benefit of hydrocarbon recovery.

(4) Environment-friendly construction and operation. The principle of environmental protection must be followed throughout the entire process of oil field construction and operation. The advantage provided by the intensive well construction mode must be fully popularized to promote green construction and operation approaches. Efforts must be exerted to achieve innovation

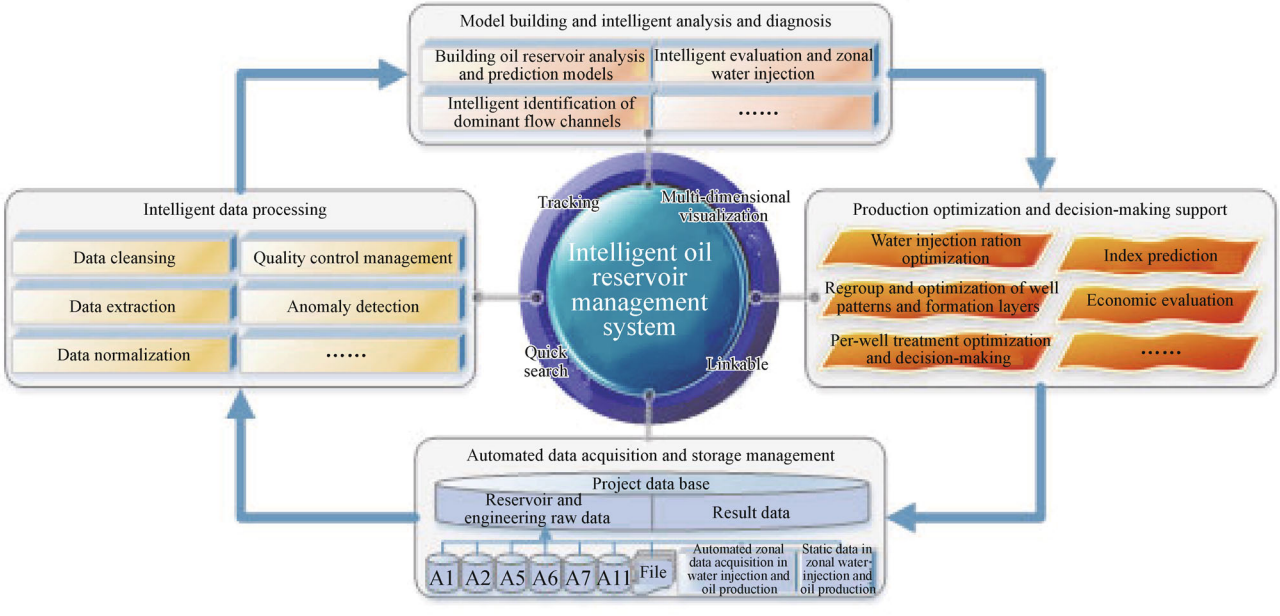

Fig. 1 Framework of an intelligent oil reservoir management system

in resource recycling and oilfield waste treatment technologies. Waste disposal, environmental risk control, and resource recycling must be disposed in a concentrated approach, and the resource exploitation must be environment-friendly.

The targets and paths of developing smart oilfields are established in accordance with the concept of "innovative, coordinated, green, open, and shared development", thereby aiding in the transition of petroleum-based cities. Smart oilfield development must be focused on to compensate for the efforts exerted to improved and strengthen the conventional resource industry.

Smart oilfield has two motivations to provide necessary conditions for the transition of petroleum-based cities. First, smart oilfield development can be boosted to enhance the conventional resource industry. Given a "digital, intelligent, intensive, and environment-friendly" path, the utilization efficiency and exploitation benefit of oil resources can be improved, and the petroleum resource recovery and the economic life cycle of the oilfield can be extended. Therefore, the information resource utilization efficiency is enhanced and intensive and green oilfield production approaches are implemented. Second, the technical and management innovations in developing smart oilfield can be strengthened to accelerate the transition of petroleum-based cities with related industry development. The efforts exerted in the smart oilfield development with tremendous investments can promote related industries, such as financial, information, advanced manufacturing, and progressive oil technical service industries, thereby enhancing urban quality and promoting the comprehensive competitiveness of such cities. Therefore, on the basis of the growth of smart oilfield, cities can gain full control of the critical aspects of city development and their transition. That is, smart oilfield development can be an important approach to the transition of petroleum-based cities.

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