ABSTRACT

Underground gas storage is a kind of artificial gas reservoir formed as commercial natural gas from long-distance pipeline reinjected into the ground. The digital twin technology is very important in digital and intelligent development of underground gas storage. The digital twin of underground gas storage which contains data layer, 3D layer, simulation layer, logic layer, interaction layer, is constructed. Based on the five layers, the digital twin system of underground gas storage is established, which contains production data management subsystem, process simulation optimization subsystem and intelligent 3D display subsystem. The digital and intelligent technology based on digital twin and digital twin system of underground gas storage integrates all the needed data with 3D models visually. And the high fidelity model of underground gas storage also helps us understand production situation, monitor hydrate risk of pipeline, manage equipment integrity, and make optimization decision. Finally, functions of offline scheme planning, online monitoring and optimization, future working condition prediction and abnormal working condition warning are realized for the whole process of underground gas storage by the digital and intelligent technology.

The digital and intelligent technology is implemented to enable the optimization of the injection-production scheme, dehydration and hydrate control for underground gas storage. Based on digital twin technology, the whole-life cycle management solution of underground gas storage is established which could greatly improve the digital and intelligent management of underground gas storage.

KEY WORDS: Underground gas storage; digital twin; digital and intelligent technology.

INTRODUCTION

The underground gas storage (UGS) is a kind of artificial gas reservoir formed as commercial natural gas from long-distance pipeline reinjected into the ground (Lei, 2018), with characteristics of large storage, wide peak regulation, high security. With the continuous construction and development of UGS globally, many challenges occur naturally, such as complex injection-production and scheduling requirements, as well as operation optimization and safety production. Especially during the large-scale and commercial transformation of UGS, it is very crucial to ensure safety production and operation optimization (Zhang, 2016; Zhang, 2017). At present, the development of UGS has the trend of digitalization and intelligence. Integrating and using the emerging intelligent technologies, such as the Internet of Things, big data, artificial intelligence, dynamic cloud computing, especially the digital twin technology, is very important to solve the problem of high precision process simulation and real-time dynamic optimization of UGS. This will be a huge step forward to improve the digital and intelligent management and operation of UGS.

Development of UGS

UGS is the most important method of peak regulating for natural gas. Currently, about 700 UGSs have been built around the world (Pan, 2016; Yin, 2013) among which the United States, the European Union, Russia and Ukraine have about 680 ones. By 2023, China has built 42 UGSs (Ding, 2002; Zhang, 2018) and formed 7 UGS groups, namely Zhong Yuan, Da Gang, Liao He and so on, with a designed inventory of 56.669 billion cubic meters and a peak-shaving capacity of 29.965 billion cubic meters. The UGSs have been built in China showed in Fig. 1.

Figure 1. The UGS built up in China (Until 2023)