



Research article

Standardized surface engineering design of shale gas reservoirs

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Abstract

Due to the special physical properties of shale gas reservoirs, it is necessary to adopt unconventional and standardized technologies for its surface engineering construction. In addition, the surface engineering design of shale gas reservoirs in China faces many difficulties, such as high uncertainty of the gathering and transportation scale, poor adaptability of pipe network and station layout, difficult matching of the process equipments, and boosting production at the late stage. In view of these problems, the surface engineering construction of shale gas reservoirs should follow the principles of “standardized design, modularized construction and skid mounted equipment”. In this paper, standardized surface engineering design technologies for shale gas reservoirs were developed with the “standardized well station layout, universal process, modular function zoning, skid mounted equipment selection, intensive site design, digitized production management” as the core, after literature analysis and technology exploration were carried out. Then its application background and surface technology route were discussed with a typical shale gas field in Sichuan—Chongqing area as an example. Its surface gathering system was designed in a standardized way, including standardized process, the modularized gathering and transportation station, serialized dehydration unit and intensive layout, and remarkable effects were achieved. A flexible, practical and reliable ground production system was built, and a series of standardized technology and modularized design were completed, including cluster well platform, set station, supporting projects. In this way, a system applicable to domestic shale gas surface engineering construction is developed.

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Shale gas refers to the natural gas contained simultaneously in mudstone, shale and other similar formations in both absorbed and free states [1–3]. Different from natural gas contained in tight sandstone formations, shale gas is characterized by longer production life, prolonged production duration, fast declination of pressures and productivities. Shale gas wells, with low well productivity, reveal high wellhead pressures, and some wells may produce gas field water and condensate oil. All these features are significantly different from reservoir features and wellhead physical properties of conventional natural gas reservoirs, and they are key factors that may directly affect surface processes. Accordingly,

surface engineering conditions for share gas are also different from those in conventional gas fields [4].

Since pressures and productivities vary significantly from early stages to middle and later stages of shale gas development, surface facilities are required to have desirable adaptability. To meet the requirements of large-scale development of shale gas with low costs and high efficiencies in China, surface engineering facilities for shale gas development should be designed in accordance with the principles of “standardized design, modularized construction”. Simplified and optimized working modes should be adopted to facilitate shale gas development in China [5–7].

1. Design difficulties

Still in its starting stage, shale gas development in China is predominantly based on technologies deployed for the

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development of conventional natural gas, with poorly developed surface gathering and transportation technologies, no sophisticated management system or no sufficient industrial standards. More explorations and summarization of experiences are required for the development of auxiliary surface supporting technologies. Generally, some difficulties should be considered in the surface engineering design in shale gas development.

1.1. Uncertainties in the capacities of a gathering and transportation system

In general, shale gas fields are characterized by high productivity in early stage, fast decline in productivity in late stage, and significant changes in productivity in the life cycle. Data from several shale gas fields in US show that approximately 80% of total production for one shale gas well may be completely recovered within 10 years, and total production remains steady at a low level. These features are different from those of conventional natural gas fields, which are characterized by steady overall productivity and lower production decline rates [8,9]. Consequently, uncertainties in capacities of surface gathering and transportation system represent a key difficulty in design. Since most shale gas fields are developed in rolling manner, difficulties in the accurate prediction of the increased productivities in later stage make it even harder to clarify the capacities of surface gathering and transportation systems to be designed.

1.2. Poor adaptability of pipeline network and station layout

In conventional gas fields, surface engineering design of gathering and transportation pipeline networks and stations can be easily performed in accordance with the development program and the performances of individual wells. However, since productivities of shale gas fields vary significantly, capacities of surface gathering and transportation systems and layouts of stations are required to be adjusted continuously to cope with the changes in productivities. Consequently, it is difficult to determine the capacities of pipeline networks and the layouts of stations. To meet the requirements for long-term development, the networks and layouts should be adapted and adjusted continuously.

1.3. Difficult matching of process facilities

Key technologies for the development of auxiliary surface engineering in shale gas development are closely related to the features of gas reservoirs. To ensure normal production, shale gas fields should be developed in scale with large areas. Under such circumstances, “factory-like” around-the-clock operations may require close matching in the construction of surface engineering facilities. As was mentioned above, significant changes in pressures and difficulties can be observed in early and late stages of shale gas development, and the capacities of gathering and transportation facilities are required to change

accordingly. Since it is quite difficult to match process facilities, those with desirable adaptability should be deployed [10]. In this way, skid-mounted facilities that can be easily relocated and installed should be used. In addition, standardized and modularized design should be adopted for surface process facilities to provide desirable capacities and operation flexibilities through fast adjustments to satisfy the demands of relevant stations.

1.4. Demands for pressure boosting in later development stage

Development of shale gas fields is characterized by extremely high wellhead pressures in early stage and fast pressure drop in later stage. These features are significantly different from those in conventional gas fields. Since shale gas fields may be under prolonged low-pressure conditions in later stage, pressure boosting should be considered as a difficulty in shale gas development. Besides, pressures in early stage of shale gas development should be fully utilized if possible [11]. With consideration to changes in pressures and productivities of gas fields, designed capacities and pressures of the gathering and transportation systems should be adjusted to cope with the pressure changes in later stage and to balance the volumes of gas among different stations.

2. Core technologies in standardized design

Standardized design of surface engineering can effectively shorten the time required for construction, minimize construction cost and ensure the quality of surface engineering facilities [12,13]. With consideration to similar station layouts, process flows and facilities in surface engineering construction in oilfields and depending on specific surface conditions, designs with uniformed standards, process flows and modularized facilities should be performed to generate one package of design patterns characterized by standardization, codification and universality.

Standardized design of surface gathering and transportation facilities in shale gas fields should be made in accordance with the overall process flow of “Cluster well site—Gathering stations—Central processing station—Export”. During the course, surface technologies such as “high-pressure gas production, medium-pressure gas gathering, wellhead heating and throttling, import gas from cluster wells to the station, centralized dehydration and pressure boosting in later stages” can be deployed. Based on the successful applications of standardized design of surface gathering and transportation facilities in shale gas fields in US, a standardized design suitable for surface gathering and transportation facilities in shale gas fields in China has been developed to ensure high-efficiency production allocation and low-cost development. Core techniques in the design can be summarized as follows: standardized well station layout, universal process flow, modularized function zoning, selection of skid-mounted facilities, serialized combinations of facilities, intensive site design and digitized production management.

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