

Research article

Application of zipper-fracturing of horizontal cluster wells in the Changning shale gas pilot zone, Sichuan Basin

Qian Bin, Zhang Juncheng*, Zhu Juhui, Fang Zeben, Kou Shuangfeng, Chen Rui

Downhole Service Company, CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu, Sichuan 610051, China

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Abstract

After several years of exploration practices in the Changning-Weiyuan national shale gas pilot zone, the industrial production has been achieved in a number of vertical and horizontal wells completed by SRV fracturing, and a series of independent shale gas reservoir stimulation technologies have come into being. Next, it is necessary to consider how to enhance the efficiency of fracturing by a factory-mode operation. This paper presents the deployment of Changning Well Pad A, the first cluster horizontal shale gas well group, and proposes the optimal design for the factory operation mode of this Pad according to the requirements of wellpad fracturing stimulation technologies and the mountainous landform in the Sichuan Basin. Accordingly, a zipper-fracturing mode was firstly adopted in the factory fracturing on wellpad. With the application of standardized field process, zipper operation, assembly line work, staggered placement of downhole fractures, and microseismic monitoring in real time, the speed of fracturing reached 3.16 stages a day on average, and the stimulated reservoir volume was maximized, which has fully revealed how the factory operation mode contributes to the large-scale SRV fracturing of horizontal shale gas cluster wells on wellpads in the aspect of speed and efficiency. Moreover, the fracturing process, operation mode, surface facilities and post-fracturing preliminary evaluation of the zipper-fracturing in the well group were examined comprehensively. It is concluded from the practice that the zipper-fracturing in the two wells enhanced the efficiency by 78% and stimulated reservoir volume by 50% compared with the single-well fracturing at the preliminary stage in this area.

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1. Introduction

Shale gas reservoirs, with ultra-low porosity and low permeability, cannot be recovered economically without hydraulic fracturing [1,2]. In 2009, the first shale gas vertical well produced industrial gas flow after fracturing, unveiling the prelude of the shale gas exploration and development in the Sichuan-Chongqing area [3]. After several years of exploration practices in the Changning-Weiyuan national shale gas pilot zone, the industrial gas production has been achieved in a number of vertical and horizontal wells completed by SRV fracturing, and a series of independent shale gas reservoir stimulation technologies have been developed [4]. On this basis,

the field test of horizontal well cluster “zipper-fracturing” has been conducted to further explore an efficient factory gas development mode [5]. The successful zipper-fracturing of a horizontal well cluster on well pad A in Changning marks a fracturing technology leap from vertical wells to horizontal wells to factory fracturing of horizontal well cluster. Shale gas reservoir fracturing is shifting from single horizontal well multi-stage fracturing to factory horizontal well cluster fracturing. It can be predicted that horizontal well cluster combined with “factory” fracturing will gradually become the mainstream technology in shale gas development.

2. Overview of cluster horizontal wells

Pad A is the first “factory” test wellpad in the Changning-Weiyuan national shale gas pilot zone in the Sichuan Basin,

* Corresponding author.

E-mail address: zhangjc_jx@cnpc.com.cn (Zhang JC).

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Table 1
Basic information of Pad A.

Well	Well spacing (m)	True vertical depth (m)	Horizontal section length (m)	Fracturing stages
Well 1	300 m away from Well 2	2491	1000	12
Well 2	/	2475	1000	12
Well 3	400 m away from Well 2	2465	1000	8

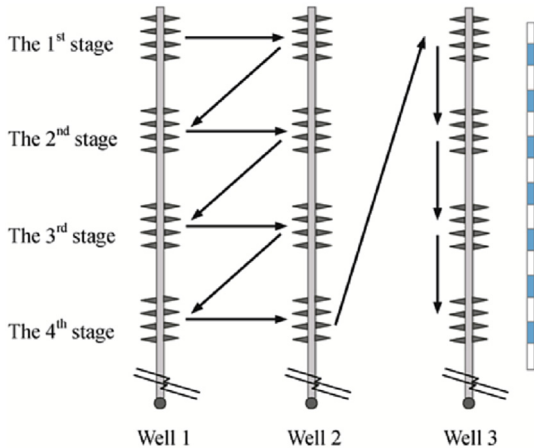


Fig. 1. Schematic diagram of zipper-fracturing operation mode on Pad A.

and also the first horizontal wellpad deployed after the completion of vertical exploratory wells and horizontal appraisal wells. It is drilled to the target Silurian Longmaxi Formation. A total of 6 horizontal wells in two rows are deployed on the wellpad. As is planned, Well 1, Well 2 and Well 3 in the updip direction will be drilled, and these wells will be fractured and tested before production (Table 1).

3. Field application of “zipper-fracturing”

3.1. Fracturing technology

Considering the ultra-low porosity and low permeability of shale gas reservoirs, the SRV fracturing technology characterized by “large-volume, high-pumping-rate, low proppant concentration, slick water slug injection” has been developed to increase fracture-reservoir contact area and generate complex fracture network. In addition, auxiliary technologies including large-volume fluid storage, continuous liquid-supply at high pumping-rate, fracturing fluid continuous mixing,

continuous sand-supply, integrated wireline bridge running and cluster perforation, multi-stage fracturing, microseismic monitoring, coiled tubing drilling, and flowback fracturing fluid recycling, have formed a complete set to match with the factory fracturing [6].

3.2. “Zipper-fracturing” operation mode

The “zipper-fracturing” operation mode was adopted in the two horizontal wells on Changning Pad A, in which fracturing operation and integrated wireline bridge running and cluster perforation were simultaneously conducted in two different wells on the same wellpad in an alternate manner and seamless transition (Fig. 1). Meanwhile, microseismic monitoring was conducted in another well, and then this monitoring well was fractured solely (Fig. 2). The specific operating procedures are as follows: ① a set of fracturing equipment was used to implement zipper-fracturing in Well 1 and Well 2; ② wireline operation equipment took turns to implement bridge running and packer setting operations; ③ bridge drilling operation was conducted in Well 1 and Well 2 when Well 3 was fractured, and then bridge drilling operation was conducted in Well 3; and ④ blowout and flowback were started immediately after the bridges were drilled through in one well, till all the three wells were all brought to flowback.

3.3. “Zipper-fracturing” ancillary surface facilities

Major surface facilities in “zipper-fracturing” operation include fracturing equipment, sand blending equipment, continuous mixing equipment, coiled tubing equipment, and surface flowback equipment, as well as auxiliary equipment such as water supply equipment, fluid tanks, sand tanks, and acid tanks. In addition, field continuous refueling equipment has been developed to guarantee continuous operation of field equipment, special multi-channel wellheads were installed to meet long-time high pumping-rate requirement of fracturing operation, and the “zipper-fracturing” operation was conducted under the unified command of the first domestic “gas factory” fracturing command center (Fig. 3).

Since multiple operations and cross-operations were involved in the “zipper-fracturing” operation, the surface facilities were arranged according to different function areas, and both operating convenience and safety were taken into consideration in the surface facility arrangement. A three-level water supply mode of water source-water pit -transiting water

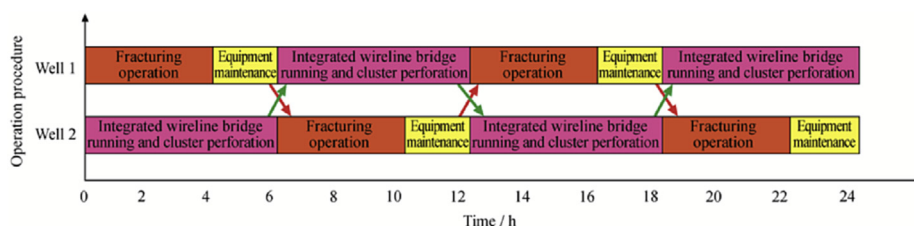


Fig. 2. Flow of zipper-fracturing operation.

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