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Research article

A plunger lift and monitoring system for gas wells based on deployment-retrievement integration

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Abstract

As a necessary step, removing liquid in the wellbore plays an important role during the production of gas wells. Plunger lift is a widely-used intermittent deliquification process for gas wells. However, the manual control way and wire logging are still utilized as a downhole monitoring way for plunger lift, which is not efficient in terms of interrupting the production. This paper presents an improved solution that logging instruments canister are deployed and retrieved by means of a new assembly. With the reciprocating plunger, logging instruments canister can be carried and deployed to the bottom of a gas well to carry out logging and sampling tasks on the production demand of a field. After the deployment and logging tasks are performed, logging instruments canister is carried back to the surface by the plunger and then data is transferred to the wellhead device near field wireless communication technology. This newly developed plunger lift system comprises plunger body, deployment sub-assembly, retrieve sub-assembly and logging instruments canister. The surface device comprises RF antenna, reader and writer. Based upon the method of deployment-retrieve integration, the new deliquification process is introduced and on-line monitoring of production dynamics can be performed including P/T measurement, downhole fluid sampling, pressure build-up, etc. without interrupting production. The general solution and engineering design parameters have been confirmed by research teams, while system prototype manufacture and workbench tests are being performed. The cost-effective way combining deliquification with dynamic monitoring is developed and contributes to increasing production and the stable productivity of gas wells. It is very significant for low-pressure and low-production gas fields to achieve automation production and management.

Keywords: Plunger lift; Deliquification; Multi-part plunger; Near field wireless communication; Deployment-retrieve integration; On-line monitoring; Pressure build-up; Dynamic monitoring; Automation

As more and more gas fields in China enter middle and late development stage, and most gas reservoirs are low-permeability and water-flooding ones with low recovery, how to enhance gas reservoir recovery becomes an urgent issue. For low pressure and low production gas wells, removing wellbore liquid, lowering bottomhole back pressure, maintaining their normal production, and prolonging their life span are of great significance to improving gas reservoir recovery [1–4]. At present, the drainage gas recovery processes include foaming, plunger lift and artificial lift. Artificial lift includes electric submersible pumping, beam pumping and jet pumping etc. [5–9]. Different from other techniques, plunger lift is a kind of intermittent lifting carrying fluid by using the reservoir energy, featuring simple design and installation, low cost, mechanical lifting interface, low economic limit etc., so it has been widely used in the middle and late development stage of gas reservoirs [10–12].

So far, oilfield service companies in China and abroad have developed a variety of plunger lift tools and supporting control techniques and put them into application [13–19]. But the existing plunger lift technologies have some deficiencies: the logging for plunger lift wells still takes the traditional wireline

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running-in process, which means when logging is to be conducted, the gas well must be shut down first. As plunger lift is an intermittent production mode in which gas wells don't produce gas in the falling cycle of the plunger, measures such as reducing shut-down times and speeding up plunger falling need to be taken to shorten off-production cycle and enhance production rate of a single well, therefore, there is contradiction between “shut-down during logging” and “reducing shut-down to enhance production”.

In view of the problem with the existing plunger lift techniques, an integrated deployment and retrieve plunger lift scheme was proposed, which makes the automatic wellbore dynamic monitoring possible during the normal drainage production. The new scheme eliminating the traditional wireline logging, enhancing operation efficiency, is conducive to increasing gas well production and automation level of gas field production.

1. Technological analysis

1.1. Technical requirement of the system

1) High efficiency production and monitoring mode. Running in and retrieving device by using the reciprocal movement of the plunger between the wellhead and the well bottom, the working plunger acts as both the drainage tool and the carrier of logging tools.
2) Multiple test functions. Different test and sampling devices can be deployed according to different test missions, including conventional temperature, pressure, wellbore sampling, and pressure build-up test etc.
3) Non-contact communication mode. A communication system with fast connection and data transmission, good anti-interference capacity, stable performance in oily and scaly hostile environments and certain anti-impact capacity should be set up.
4) Simple maintenance. Parts like device, power source, deploying and retrieving components can be easily replaced.

1.2. Suitable conditions of the technology

According to the production conditions of gas wells and wellbore parameters, working condition of plunger lift tool were presented, namely: tubings 73.03−101.60 mm in diameter, the maximum well depth of 2500 m, the maximum well inclination of 30°, the gas/liquid ratio of over 250 m^3/m^3, the liquid production of less than 300 m^3/d, and the working temperature of −25 °C−90 °C.

2. Design of the system

2.1. Mechanical structure

The system is composed of downhole plunger and surface corollary devices. When carrying out a deploying task, deploying assembly is connected between the plunger and the instrument canister. When retrieving a device, the deploying assembly is replaced with retrieving assembly (Fig. 1). The main surface corollary part, ring-shape antenna is fixed inside the wall of the lubricator.

There are some inner holes inside the plunger itself (Fig. 2) for fluid passing, which is good for enhancing the downgoing speed of the plunger. The plunger top is connected with the plunger fishing head, and there are ring-shape non-equilateral ladder grooves in even interval in the outer surface of the plunger, which mainly function to remove sand and scale stick to the inner wall of tubing during the downgoing and upgoing movement of the plunger. There are capillary groups on the outer surface of the plunger, which, similar to nozzles, allow high speed jetting of the fluid to pass through the inner holes into the space between the plunger and the tubing inner wall, and to wash the sand and scale around the plunger and lower instrument canister. The structure parameters of the tool are: outer diameter of 60 mm, inner diameter of 20 mm, length of plunger of 430 mm, instrument canister length of 280 mm, deploying/retrieving assembly length of 140 mm.

The instrument canister assembly is made up of a working barrel fishing head, a buffer spring, a instrument canister, a downhole device and a bottom plug (Fig. 3). Downhole devices include pressure/temperature sensors, and sampling devices etc. The fishing head of the canister is a structural part conformable with API standard. When the instrument canister assembly can't be retrieved with the retrieving assembly, the

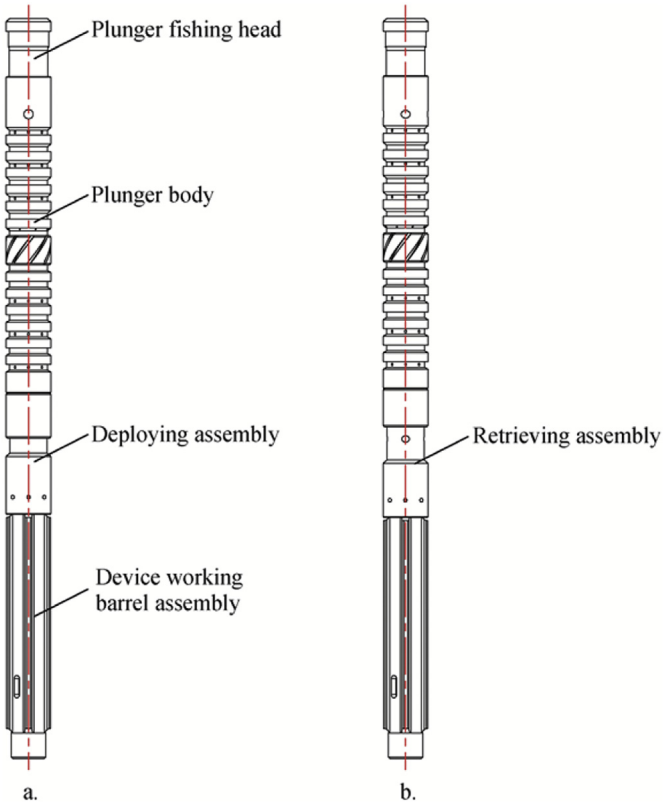

Fig. 1. The plunger with a deploying assembly (a) and the plunger with a retrieving assembly (b).