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A novel technology of combining foam injection and compression to lift liquid in water flooded gas wells

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ABSTRACT

This article present a novel technology of combining foam injection and compression to lift liquid in water flooded gas wells in order to bring them back to production. In this technology, the natural gas in the gathering pipeline could be supplied to the natural gas generators. And then the generators provide electrical power to the injection systems which are skid mounted designed. The technology is helpful and cost effective to bring water flooded gas wells, especially to those located at a remote areas where electrical power is not available, back to production. In this paper, a typical water flooded gas well was selected to illustrate this technology and the successfully application of the technology indicates that engineers could bring water flooded gas wells back to production by using this novel artificial lift technology.

1. Introduction

Liquid loading, one of the major causes for reduction or loss of production in the gas wells, has caught much attention in recent decades, with on-going demand to maximize gas production from existing wells. Many gas wells cease producing economically long before their reservoirs have depleted for the reason that the liquid in the wellbore cannot be lifted with gas when reservoir pressures and gas velocities decrease gradually with time. Artificial lift applications for removing liquid from gas wells around the world are becoming more and more important (Orta et al., 2007; William, 2010). Proper application of artificial lift technology to a loaded up gas well can be one of the most profitable ventures that a company undertake in its overall investment opportunity portfolio (William, 2010). Several artificial lift techniques such as reciprocating rod lift, foamer injection, plunger lift, gas lift, small-ID tubing, flow controllers, submersible pumps, swabbing and jetting have been developed to remove liquid from the wellbores and the annulus of gas wells. Some of these methods require energy to pump out liquid, others require installation of costly equipment in the wells. Foamer injection is one of the cheaper and simpler method that have been used successfully to remove the wellbore liquid (Shameem and Jiansui, 1999). In foamer injection technology, foaming agent converts liquid into foam lowering density of the bottom hole hydrostatic pressure and increasing brine unloading from the well. The foaming by surfactant leads to lower density of the liquid droplet as liquid was trapped in the thin-film of foam, or creates smaller droplet by decreasing surface tension of air–water interface (Jiang et al., 2013). However, the method of foamer injection cannot be used if there has no gas flow such as in water flooded gas wells. All in all, the artificial lift techniques mentioned above require electrical power or costly equipment to remove liquid from gas wells and they cannot be used cost effectively when electrical power is not available. The foamer injection technology cannot bring water flooded gas well which has no gas flow back to production, though it's a cheaper and simpler method compared with other techniques. Suitable tools and artificial lift techniques to deliquify these types of water flooded gas wells, where electrical power is not available, have become increasingly important in the foreseeable future for the reason of the decline in average gas production rates and the current and forecasted strong demand for natural gas as a clean hydrocarbon source.

The aim of this paper is to investigate a new technology combining foam injection and compression to lift liquid in water flooded gas wells. Compared with other techniques, this new technology is expected to be especially useful and cost effectively to bring the water flooded wells which have low pressure in reservoirs and electrical power is not available in the fields back to production.

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2. Principle and procedures

2.1. Principle

The technology of combining foam injection and compression, considering the foaming agent and the liquid in the wellbore have to be mixed and removed with natural gas flow from the wellbore, contains two injection systems: foaming/de-foaming agent injection system and compressed natural gas injection system, shown as in Fig. 1. The natural gas in the gathering network from previous production is supplied to the natural gas generators to provide electrical power for the injection systems. The natural gas that is compressed and injected into the well is from previous production in the gathering network, too.

The foaming/de-foaming agent injection system consists of a natural gas generator, natural gas pre-processing devices including a separator, a pressure control valve, a filter and a buffer tank, and agent injecting devices including plunger metering pumps. Firstly, the wet inlet gas stream from gathering pipeline passes through the efficient separator where free liquids and solid particles are removed. This is a very important part of the system since the free liquids and solid particles may damage or destroy the natural gas generator. Then, the gas stream is sent through the filter to keep the remained liquid out of the natural gas generator and the buffer tank after taking the outlet gas stream from the separator across the pressure control valve to keep the inlet pressure for natural gas generator at a suitable limit. Till now, the natural gas pre-processing program is end and it could be supplied to the natural gas generator which could provide electrical power to the plunger metering pumps. The foaming agent could be injected into wellbore and annulus while the de-foaming agent could be injected into the pipeline which connecting Christmas tree and the indirect heater with a T-joint by the plunger metering pumps through the injection pipeline.

The gas injection system consists of a natural gas compressor which compresses natural gas and injects it into annulus of the gas wells, a natural gas generator to provide electrical power to the natural gas compressor and the natural gas pre-processing devices same as the foaming/de-foaming agent injection system. The inlet gas stream from gathering pipeline has the pre-processing program same as in the foaming/de-foaming agent injection system. The natural gas, in this system, could be compressed and injected into annulus by the natural gas compressor through the compressed natural gas injection pipeline. What's more, it could be supplied to the natural gas generator which could provide electrical power to the natural gas compressor.

Both injection systems are skid mounted designed making them could be used repeatedly and transported easily so that the technology of combining foam injection and compression could be used to bring water flooded gas wells back to production and could not be restricted by the bad geographical circumstance, shown as in Fig. 2. The natural gas in the gathering pipeline could be supplied to the natural gas generators which could provide electrical power to this system making the technology of combing foam injection and compression has the unique advantage in bringing water flooded gas wells which located at remote areas where industry power is not available back to production.

2.2. Procedures

The general procedures involved in performing the technology of combining foam injection and compression jobs are:

- Step1: Injecting foaming agent into the wellbore and the annulus.
- Step 2: Compressing and injecting natural gas into the annulus.
- Step 3: Injecting foaming agent and compressed natural gas during deliquification.
- Step 4: Producing natural gas normally.

In the first step, the foaming agent is injected in the wellbore and the annulus of the water flooded gas well, shown as in Fig. 3a. In this step, foaming agent is used to converts liquid in the wellbore into foam in order to lower its density and create smaller droplet by decreasing surface tension of air–water interface. The two valves for injecting foaming agent are being opened to inject foaming

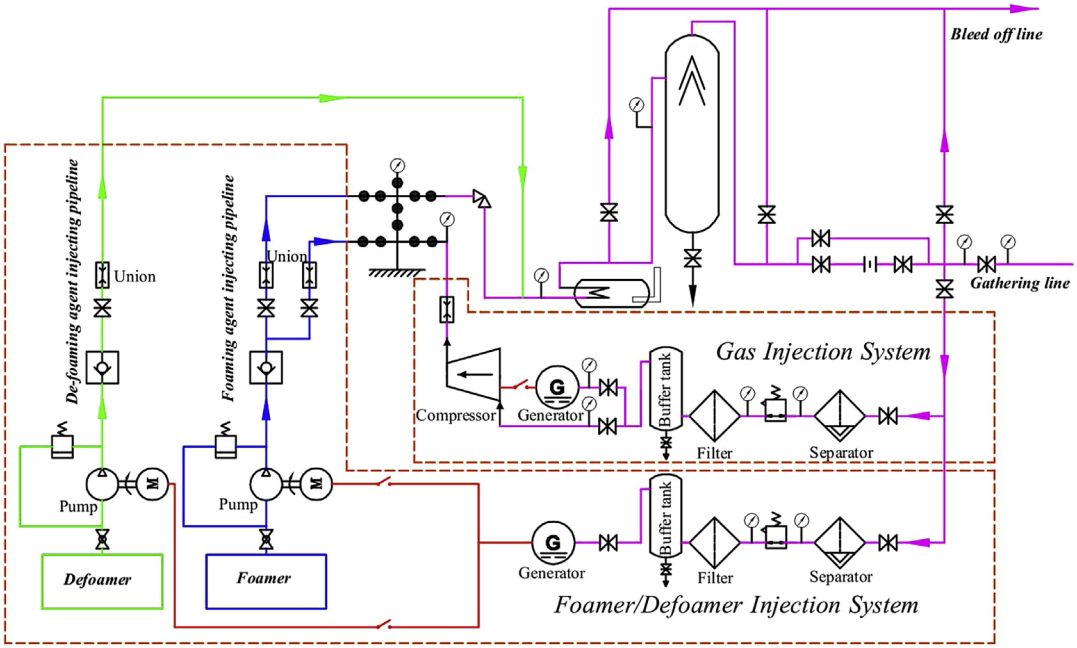

Fig. 1. Schematic diagram of the combining foam injection and compression technology units.