

RESEARCH ARTICLE

Application of Solid Foam Generators for Liquid Removal from The Bottom of Gas Condensate Wells

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Abstract

This article examines the application of solid foam generators for liquid removal from the bottom of gas condensate wells. The study focuses on challenges arising at the late stages of gas condensate field development, such as increasing well flow rates and reducing water cut. The article presents the results of pilot industrial tests of solid foam generators, analyzing their efficiency and technical-economic performance. Special attention is given to the mechanism of action of foam generators and their impact on reducing operational costs. Recommendations for the optimal use of solid foam generators in various gas condensate field conditions are proposed. The findings indicate a significant potential for using solid foam generators to enhance profitability and extend the operational life of gas condensate wells.

KEY WORDS

Solid foam generators, gas condensate wells, liquid removal, foam-forming compositions, surfactants.

INTRODUCTION

In the late stages of gas field development, the depletion of reservoir energy is inevitable. The upward flow velocity in the tubing (production string) decreases to the point where it is no longer sufficient for complete liquid removal. As a result, water and condensate accumulate at the bottomhole, leading to gradual liquid loading and the eventual self-killing (shutdown) of the well.

METHODS

The presence of formation water or residual technogenic fluids

in the bottomhole zone (BHZ) significantly accelerates the self-killing process. The contact of low-mineralized fluids with the rock degrades the matrix, triggers intensive sand production, disrupts the uniformity of reservoir drainage, and leads to the erosive wear of equipment [1].

To maintain the operation of the well stock, various geological and technical measures (GTM) are employed: water shut-off, cyclic dry gas injection, and the use of concentric or plunger lifts. However, these methods require significant capital

investment and have technical limitations. The most common and rapid method—atmospheric blowdown—causes environmental damage, leads to irreversible gas losses, damages the BHZ due to sharp pressure drawdowns, and provides only a short-term effect.

The most accessible and technologically effective alternative is the use of foaming surfactants. Dissolving in the bottomhole fluid, surfactants interact with the upward gas flow to form a stable foam that is easily carried to the surface [2, 3].

Classification and Selection of Surfactants. In field practice, two groups of reagents are most frequently used:

1. Anionic Surfactants (AS): These dissociate in water (e.g., sodium decyl sulfate, sulfanol). Their foaming capacity is high but depends critically on the salt composition of the formation water, which can reduce their solubility.

2. Non-ionic Surfactants (NS): These do not form ions (e.g., ethoxylated alcohols, alkylphenols). They are easier to produce and can form foam even in the presence of gas condensate [4, 5]. The main disadvantages are lower water solubility and the high cost of certain brands.

The properties of the resulting foam (stability, density, rheology) depend on the reagent type, bottomhole

temperature, and the presence of stabilizers [6]. Surfactants can be delivered in liquid form (along with methanol) or dropped as solid surfactant sticks (SSS) or balls. The method of selective SSS dropping is particularly relevant for low-rate wells, as it eliminates the need for environmentally harmful atmospheric blowdowns.

Technological Support. The selection of a surfactant requires a preliminary analysis of well parameters: flow rate, fluid composition, thermobaric conditions, water mineralization, and tubing design.

For the introduction of SSS, the company "ITIS" offers the compact SHU-1 wellhead gateway (operating pressure 35 MPa, weight 30.5 kg) with manual control (Fig. 1). A critical condition: SSS is effective in wells with a sump depth of no more than 10 meters. In deeper sumps, the sticks fall to the bottom where, due to the lack of fluid movement, foam formation is hindered [7].

The market features SSS in the form of gels in water-soluble shells (e.g., "TSUNAMI" brand, Fig. 2) and compressed solids (Fig. 3, 4). Their dissolution time ranges from 40 minutes to 6 hours (optimal bottomhole temperature is approximately 50 °C).



Fig. 1: SHU-1 wellhead gateway.



Fig. 2: Gel surfactant in a water-soluble shell.

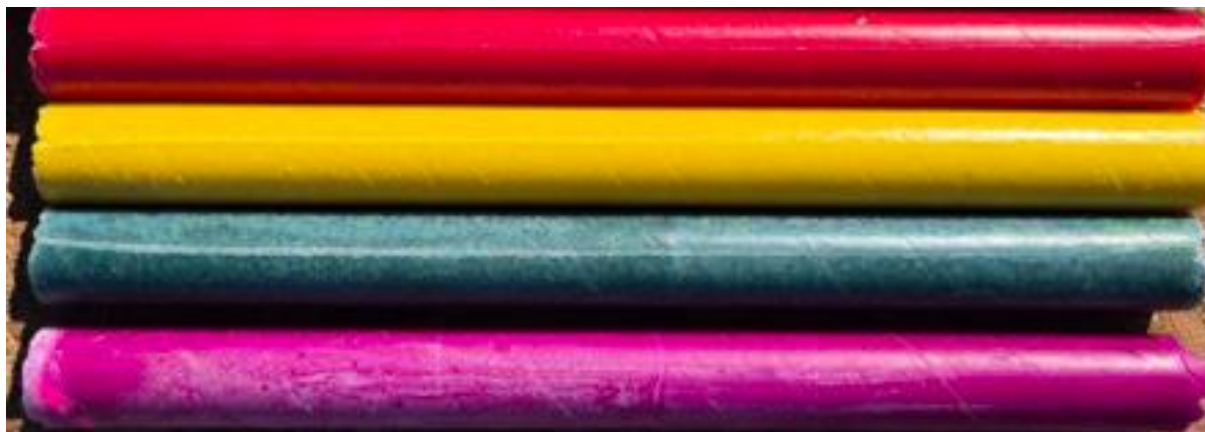


Fig. 3: SSS without cardboard shell.

For gas condensate wells, the company "VariChem" has developed a line of specialized solid sticks [8]:



Fig. 4: SSS in a cardboard shell.

- "VF-118 (Red)": A super-foamer that works with condensate content up to 50%.
- "GVF-234 (Yellow)": A universal reagent for a wide pressure range (up to 70% condensate).
- "F-123 (Green)": A fast-dissolving stick for gas wells (up to 40% condensate).
- "F-119 (Violet)": Optimal for shallow wells with low pressure and temperature (up to 30% condensate)

RESULTS AND DISCUSSION

1. Akchalak Field

The application of "F-123 (Green)" sticks ensured stable liquid removal. The pressure differential between the wellhead and the flowline ($dP = P_{wh} - P_{fl}$) increased from 2 to 6 kgf/cm² (Fig. 5, 6). The well's operating mode stabilized, wellhead pressure increased, and the need for atmospheric blowdowns was eliminated.

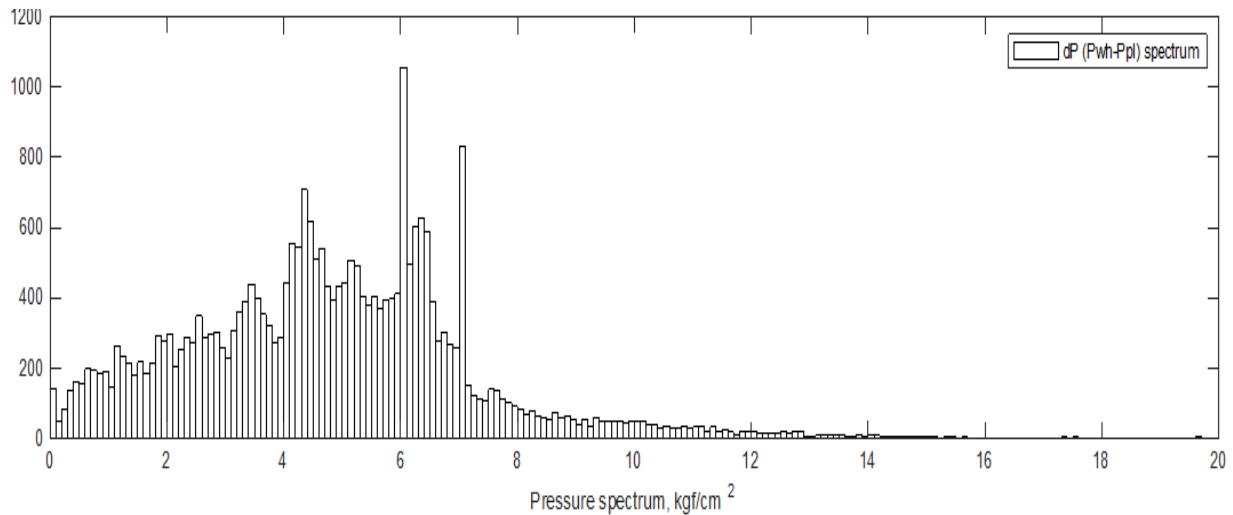


Fig. 5: Distribution spectrum of $dP(P_{wh} - P_{fl})$ during the SSS dosing period.

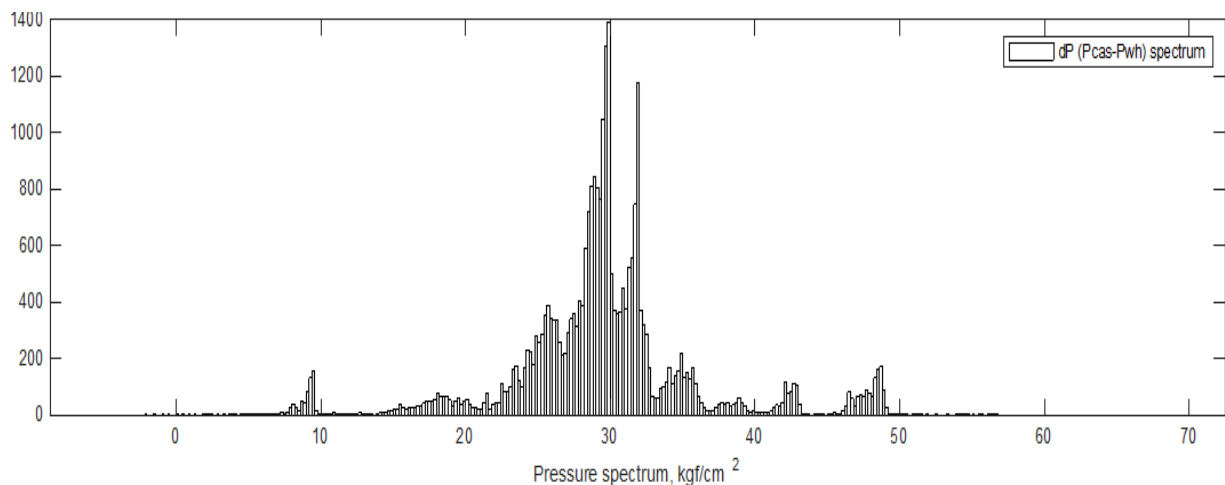


Fig. 6: Distribution spectrum of $dP(P_{an} - P_{wh})$ during the SSS dosing period.

2. West Barsakelmes Field

Dosing with "VF-118 (Red)" led to an increase in the pressure difference between the tubing and the annulus by 2.77 kgf/cm² and a reduction in the differential between the annulus and wellhead pressure by 18.03 kgf/cm² (Fig. 7, 8). The well transitioned to a continuous liquid removal mode,

with operating pressure maintained above 50 kgf/cm². It was noted that increasing a single dose to two sticks was economically impractical. Daily flare blowdowns (previously conducted 1–2 times per day) were discontinued.

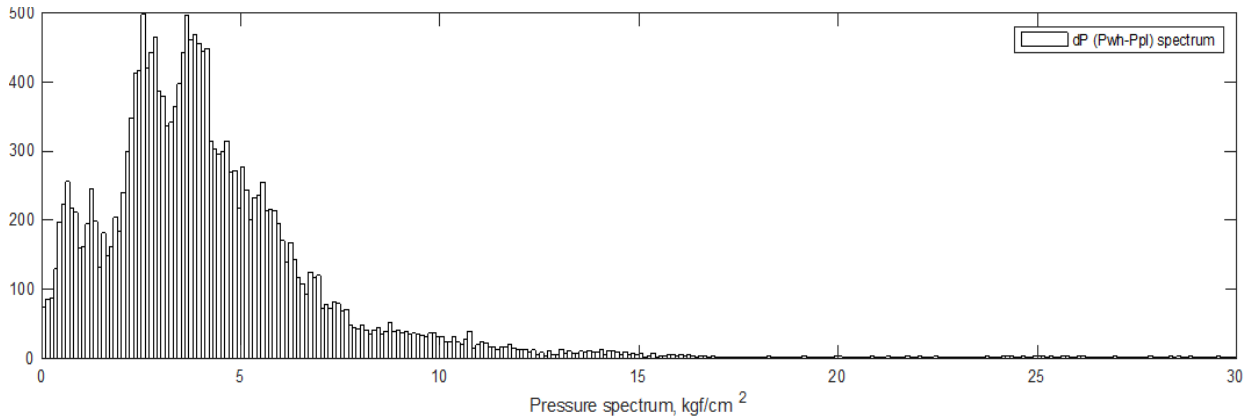


Fig. 7: Distribution spectrum of dP(Pwh – Pft) during the SSS dosing period.

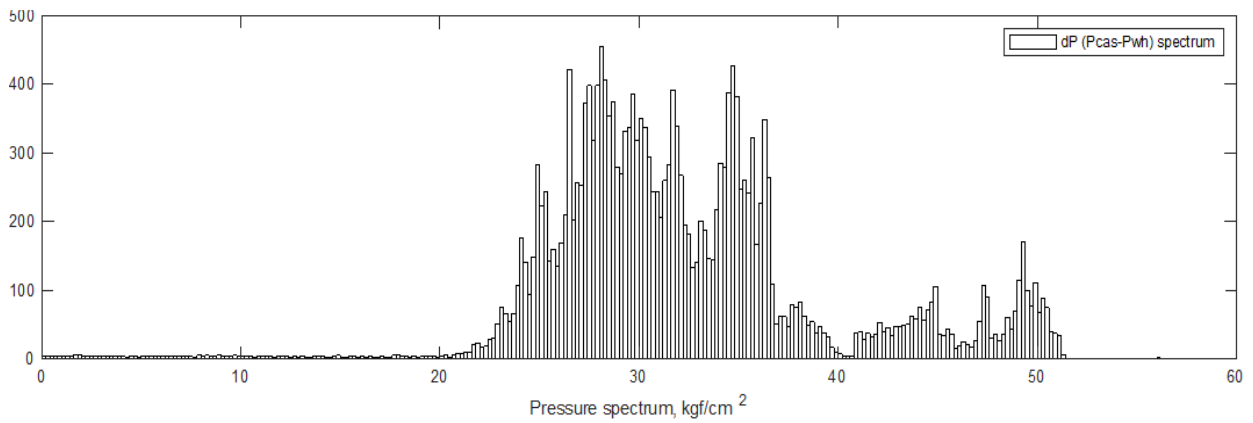


Fig. 8: Distribution spectrum of dP(Pan – Pwh) during the SSS dosing period.

3. Kalandar Field

A comparative analysis of well operation with blowdowns versus the application of "FLURO-STICKS" (Altachem) [9]

showed a clear advantage for the chemical method. During the blowdown period, the median dP(Pwh – Pft) was only 1.8 kgf/cm², whereas, with the dosing of one SSS stick per day, this figure rose to 4.1 kgf/cm² (Fig. 9–10).

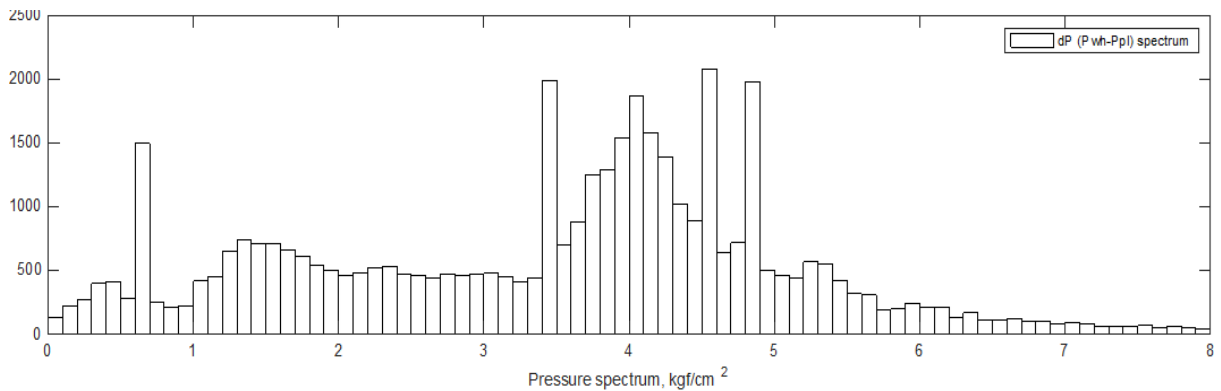


Fig. 9: Distribution spectrum of dP(Pwh – Pft) during the SSS dosing period.

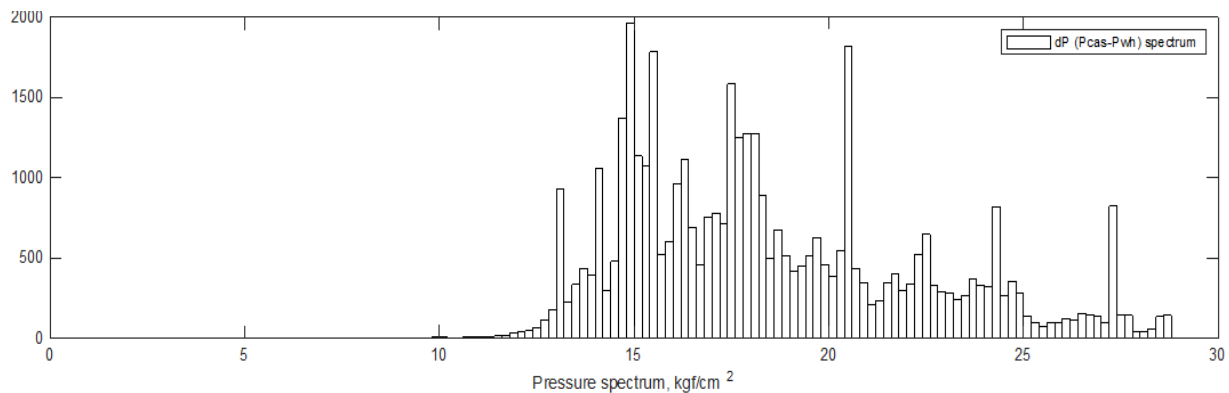


Fig. 10: Distribution spectrum of $dP(P_{cas} - P_{wh})$ during the SSS dosing period.

Standard SSS Treatment Algorithm:

1. The well is briefly blown down to the flare and then shut in.
2. The calculated number of sticks is loaded into the lubricator and dropped to the bottomhole.
3. A technological pause is observed to allow for the reagent to dissolve.
4. The well is restarted to the flare to discharge the formed foam and mechanical impurities.
5. The well is switched to the production flowline (in some cases, sticks can be dropped without stopping production).

CONCLUSION

Based on the study, the following conclusions can be drawn:

- The use of solid foamers proved highly effective in removing liquid from the bottomhole of gas condensate wells.
- The application of surfactants significantly reduces well water-cut and increases gas flow velocity, contributing to an increase in the overall hydrocarbon recovery factor.
- SSS technology optimizes well operation processes, reducing the costs of additional liquid removal measures and increasing overall productivity.
- Further research is recommended to determine the optimal application conditions and dosing parameters for various types of wells and reservoirs. These results confirm the feasibility and prospects of using solid foamers in the gas and oil industry.

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