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# Biodegradable Solid Foaming Product for the Evacuation of Water from Natural Gas Wells

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## Abstract

*A special problem currently faced by the natural gases extraction industry is that most of the natural gas wells accumulate water in the perforated area and in the tubing. The higher the amount of accumulated water, the higher is also the hydrostatic pressure exerted by the water column on the productive layer. Sometimes, this pressure can reach a value equal to the layer pressure and then the well stops flowing.*

*The aim of this paper is to present a solid biodegradable product for the evacuation of water accumulated in natural gas wells, leading to a decrease of the dynamic bottom pressure and consequently to an increase in the wells' productivity.*

*The paper also presents an experimental installation realised for the testing under dynamic conditions of the product, as well as the results of a treatment by foaming of water accumulated at an actual productive well from the Transylvanian Basin, using the developed product.*

**Key words:** *biodegradable foaming agent, natural gas well, gas production.*

## Introduction

A trend that can be noticed nowadays on national and international level with regard to the exploitation of natural gas deposits is to keep existing wells in production and less to dril new wells on structures that are already in exploitation.

To keep wells in production at their maximal potential means to exploit them at a minimal dynamic bottom pressure.

For most of the gas wells in the Transylvanian Basin and from the Extra-Carpathian area, the exploitation at maximal potential is realised by avoiding the accumulation of liquid impurities in the perforated areas and in the tubing. These liquid impurities can lead to an increase of the dynamic bottom pressure up to values close to the deposit pressure and thus to a considerable reduction in the flow of produced gases, even to stopping the gas production at that well.

Currently there exist several methods for evacuating the deposit water accumulated in the well, such as:

- gas lifting with nitrogen;
- pluger-lift;
- using solid or liquid foaming materials.

The method that is most economic, easiest to apply and that does not require supplemental investments at the well is the method using solid foaming materials.

It is known that foams have multiple uses in the natural gas and oil extraction industry, as drilling fluids, fluids for stimulation (fracturing) and especially in the operations of eliminating water accumulated in the well hole at wells that produce gases in depleted productive structures, so that the gas flow in these wells can be maintained at high levels [3, 4].

Foaming agents are also successfully used in the exploitation of coal mines, more precisely for the control of the dust in subterraneous coal mines.

The first solid foaming agents realised in Romania and applied in production in 1977 were based on polyethoxilate phenols, with a density of around 1200 kg/m$^3$. (invention patent no. RO119864 B1 [1]). These materials were successfully used in most natural gas wells in the Transylvanian Basin, in Moldavia and in the Extracarpathian area.

The Regulation 1907/2006 of the European Parliament and of the European Council [6] restricted, after 2007, the commercialisation and usage as substances or components of the chemical compounds of etoxilate nonilphenol, which is the main component within the structure of the mentioned foaming agents (that were prepared as sticks and will therefore be further on designated as such).

Furthermore, the Regulation 648/2004 of the European Parliament and of the European Council regarding detergents [5] contains a provision requiring that the final aerobic biodegradation rate of surfactants and of detergents that contain surfactants has to reach at least 60% in maximum 28 days.

Since the etoxilate nonilphenol has a much reduced biodegradability (around 30%), the authors have reoriented their researches towards other compositions of solid foaming products that would have a similar or better effect compared to phenol-based products and that would respect the provisions in the above-mentioned regulations.

The current paper therefore aims to present a result of these researches, the solid biodegradable product called STIMGAZ (invention patent no. RO127517 [2]) and the results achieved through its usage in a productive gas well.

## Theoretical Considerations

The foaming sticks are solid foaming materials, based on non-ionic tensioactive agents, cast as cylindrical sticks, with variable diameters and lengths. Their melting temperature is comprised between 40 and 55°C and they can be produced in a larger range of densities, function of the equipment manner of the well where they are needed.

The installation for producing the biodegradable solid foaming products is presented in Figure 1.

The sticks are introduced periodically in the wells, the time intervals varying function of the noticing of a significant decrease in the gas flow due to fluids accumulation and also of the increase of the pressure difference between the tubing and the column.

The sticks can be introduced into the wells manually, by manoeuvring valves on the eruption head of the well or by using an automated launcher, without there being a need to stop the production at the well.

Figure 2 presents an automated launcher for the biodegradable foaming agent developed as presented in the paper, realised at SC ARMAX GAZ SRL.

The foaming stick is dissolved in the water accumulated in the well and this water is then transformed into foam with the help of the agitation created by the natural gas.

**Fig.1.** Installation for producing the biodegradable solid foaming sticks presented in the paper

**Fig.2.** Automated launcher for solid biodegradable foaming sticks

In order to finalise the recipe for these biodegradable solid foaming products, there has been realised a testing installation on which a series of tests under dynamic conditions have been unfolded (fig.3).

**Fig.3.** Testing installation

**Fig.4.** Detail presenting the foaming inside the testing installation

Foam has a density of up to 100 times smaller than deposit water, so the presence of foam will decrease the dynamic bottom pressure accordingly and the accumulated water, transformed into foam, can then be evacuated. Figure 4 presents a detail of the transformation of water into foam.

The effect of this treatment is expected to be an improvement of the gas flow, noticeable in the values of the pressure at the tubing-column and an increase of the well's production flow, on average by 40-50% or even up to 100% in some situations.

The STIMGAZ product respects the EU provisions regarding biodegradability (as proven by the Test report 671/B from 19.11.2012 emitted by ECOIND) and is realised in 3 density varieties:

- superunit STIMGAZ S sticks, with densities between 1.0-1.15 g/cm$^3$;
- subunit STIMGAZ D sticks, with densities between 0.9-1.0 g/cm$^3$;
- subunit STMGAZ U sticks, with densities below 0.9 g/cm$^3$.


**Fig.5.** STIMGAZ sticks

The reasons for creating the sticks on density ranges are as follows [2]:

- In very many cases, the wells in which water accumulates in the perforated area have a very large sack. If using "heavy" (superunit) sticks in these wells, they would be lowered in the well sack where, however, there is no gas to allow the transformation of water with foaming agent into proper foam. Therefore, for such wells it would be better to use a column of sticks with different densities.
- In some situations, the perforated productive area is large; if this area is inundated and the gases flow only at the upper part of the area, using superunit sticks would have the same effect as described above. Therefore, in these wells it would be better to use a column of subunit sticks that would dissolve in the area with maximal agitation of the well.
- In some cases, the flow along the extraction tubes occurs as gasified water plugs or as water plugs alternating with gas plugs. In these situations, the only products that would have a positive effect are subunit sticks with densities as low as possible.

Among the advantages of using solid foaming agents compared to liquid foamers there can be mentioned following ones:

- As opposed to the usage of liquid foamer, the introduction of solid foaming sticks into the well does not require any apparatuses or devices (dosage pumps, lubricators or similar ones);
- The high viscosity of liquid foamers imposes its dilution before introducing it into the well at a foamer-water ratio of 1:5-1:10;
- The duration for the solid foamer to reach the water and gas mass is much shorter than in the case of using liquid foamers;
- Due to the shape of the sticks there are no special problems related to storage, as opposed to liquid foamers (barrels, adequate storage spaces etc.).

## Experimental Researches and Results

The experimental researches have targeted the efficiency of using the biodegradable solid foaming materials at several natural gas wells from the area of the Transylvanian Basin.

For this, there has been carried out a foaming treatment of water using a column of 3 sticks of various densities. Before applying the foaming treatment, the well was producing natural gas at a flow of 4652 $Nm^3$/day and had the perforated area completely inundated.

After the foaming treatment there has been carried out a dynamic control, noticing that almost the whole amount of accumulated water was eliminated from the well.

The dynamic parameters of the well, before and after the treatment with solid foaming sticks, is presented in table 1. The influence of the treatment with solid foaming sticks on the pressure along the well's depth can be seen in table 2 and figure 6, respectively.

**Table 1.** Dynamic parameters of the studied well

| Dynamic parameters | Before treatment with solid foaming sticks | After treatment with solid foaming sticks | Measurement unit |
|---|---|---|---|
| Pd (max) | 11.5/29 | 20/29 | bar |
| P1/P2 | 9.6/9.3 | 20/9.7 | bar |
| Perforations | 1680-1725 | | m |
| Tubing | 2 7/8 x 1716 | | in x m |
| Mirror | 1755 | | m |
| Flow rate | 4652 | 13827 | $Nm^3$/zi |
| Nozzle | 6 | | mm |

**Table 2.** Pressure values before and after using the foaming sticks

| Depth | Before foaming | | | After foaming | | |
|---|---|---|---|---|---|---|
| | Pressure | Density | | Pressure | Density | |
| | | Theoretical | Real | | Theoretical | Real |
| m | bar | kg/m3 | | bar | kg/m3 | |
| 0 | 9.5 | 6.4 | | 18.47 | 13.02 | |
| 250 | 9.87 | 6.68 | 8.45 | 19.05 | 13.57 | 16.82 |
| 500 | 10.12 | 7.05 | 8.9 | 19.48 | 14.06 | 17.2 |
| 750 | 10.62 | 7.4 | 9.2 | 20.05 | 14.58 | 17.76 |
| 1000 | 10.87 | 7.82 | 9.4 | 20.65 | 15.11 | 17.94 |
| 1250 | 11.12 | 8.1 | 10.15 | 22.04 | 15.62 | 19.24 |
| 1500 | 12.7 | 8.46 | 10.94 | 23.18 | 16.12 | 21.73 |
| 1580 | 13.5 | 8.7 | 11.12 | 25.6 | 16.68 | 23.18 |
| 1630 | 13.92 | 9.1 | 11.64 | 26.2 | 17.35 | 56.2 |
| 1680 | 27.95 | 19.26 | 925.3 | 23.06 | 17.44 | 51.17 |
| 1700 | 29.2 | 22.76 | 964.5 | 23.48 | 17.56 | 36.2 |
| 1720 | 31.75 | 25.72 | 972.7 | 23.78 | 17.72 | 54.14 |

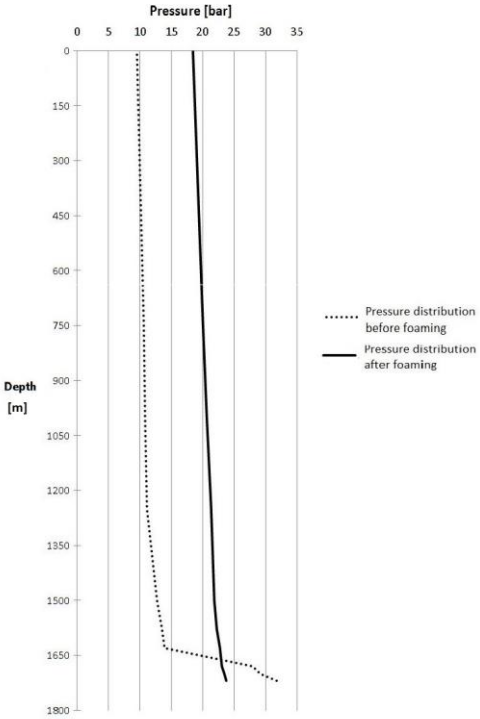


**Fig. 6.** Graphical representation of the pressure variation in the studied well

The pressure in the tubing has increased from 10.5 bar to 20 bar, the layer pressure at a depth of 1720 m has decreased from 31.75 bar to 23.78 bar, while the flow at the well increased to 13827 $Nm^3$/day.

## Conclusions

The paper presents biodegradable solid foaming products that were patented through the invention patent RO127517 [2]. These products, when introduced into the well through the extraction pipes, under pressure, transform the water accumulated in the well into foam, determining a reduction of the hydrostatic pressure exerted by the water on the layer and an increase of the amount of produced hydrocarbons.

Due to the wide range of densities in which this product can be realised, it allows, in conditions of reduced pressure (depleted wells) an efficient evacuation of water, regardless of its flowing structure (accumulated water, gasified water plugs or alternate water-gas plugs) while after the foaming treatment there can be also noticed an increase in the flow of extracted gases of around 40-50% compared to the situation before the foaming treatment.

At present, the evacuation of water accumulated in wells using solid foaming materials keeps gaining track, becoming the most widely used such technology for productive natural gas wells.

## References

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# Produs spumogen solid biodegradabil destinat evacuării apei din sondele de gaze naturale

*O problemă deosebită cu care se confruntă la ora actuală industria extractivă de gaze este aceea că majoritatea sondelor de gaze naturale acumulează apă în perforaturi și în tubing. Cu cât cantitatea de apă acumulată este mai mare cu atât presiunea hidrostatică exercitată de coloana de apă asupra stratului productiv este mai mare. Sunt situații când aceastp presiune egalează presiunea de strat iar sonda nu mai curge.*

*Scopul acestei lucrări este prezentarea unui produs solid biodegradabil destinat evacuării apei acumulată în sondele de gaze naturale având ca efect scăderea presiunii dinamice de fund și respectiv creșterea productivității sondelor.*

*Lucrarea prezintă deasemenea un stand experimental realizat în scopul testării în condiții dinamice a produsului și rezultatele unui tratament de spumare a apei acumulate într-o sondă productivă din Bazinul Transilvaniei, folosind aceste produse.*