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**LABORATORY RESEARCH ON THE INFLUENCE  
OF NEW BG-027 POLYMER ADDITION  
ON TECHNOLOGICAL PARAMETERS OF DRILLING MUD  
DEDICATED TO DIRECTIONAL DRILLING  
IN SHALE ROCKS\*\*\***

## **1. INTRODUCTION**

In modern drilling practice the number of directional wells is constantly rising. This trend is connected with a series of advantages of this technology, such as:

- access to reservoirs unobtainable for conventional drilling because of difficult geological conditions (faults, salt domes) or located under waters, highly urbanized or environmental protected areas,
- increasing contact zone between well and reservoir, enhanced well productivity,
- reduced drilling device footprints due to multilateral wells,
- the possibility to explore unconventional resources like shale gas or oil,
- performing relief wells in the case of uncontrolled eruption appearance (e.g. Deepwater Horizon disaster).

The level of technological difficulty during directional drilling rises significantly with well depth and the inclination. Those factors demand using state of the art technologies which guarantee achieving desired targets without time-consuming and expensive complications [1].

The success of a directional drilling operation depends largely on the used drilling fluid. With their selection, extremely important is the emergence of different fluid flow velocity distribution in inclined and horizontal sections than it is in vertical wells. This causes the need to maintain a low plastic viscosity, higher apparent viscosity and yield point of mud at low shear rates. Low shear rates occur when the drill string comes into contact with the wall of the wellbore or lies horizontally. Maintaining a high apparent viscosity values also allows to effectively carry out rock cuttings up the well. Not less important is to provide the wellbore wall stabilization, which can be achieved by using mud with a sufficiently high gel strength.

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What is more, gel strength must be also low enough to restart circulation without unnecessary energy costs [2].

Taking into consideration all these requirements, a promising solution could be using a new BG-027 polymer as an addition to drilling fluids which will help to regulate their parameters. The subject of the research was to study its impact on the rheological properties of 5% bentonite suspension.

BG-027 is a small molecule anionic-cationic copolymer containing sulfonic groups and amino groups with a low steric hindrance in side chains. It contains 25% of the cationic groups.

## 2. LABORATORY RESEARCH

Initially, the optimum concentration of the polymer solution has been determined, giving the most profitable changes in rheological parameters (from the point of view of the application in the directional drilling) compared to pure bentonite suspension. It was achieved by preparing muds based on 5% suspension of “Bentopol Zębiec” bentonite with a different concentration of polymer in the range 0.5–1.5%. Subsequently, standard mud tests have been performed.

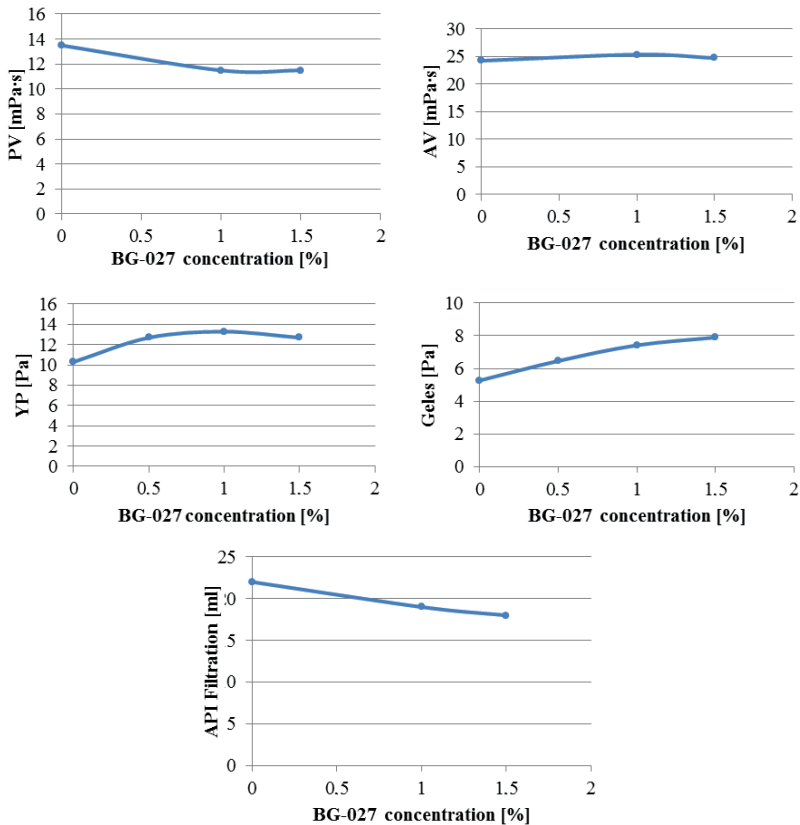


Fig. 1. Influence of BG-027 polymer concentration onto parameters of bentonite suspension

The following tests has been carried out: rheological parameters, filtration, resistance of the muds with BG-027 polymer addition to temperature and the presence of mono- and di-valent salts. All tests have been developed in accordance to API standards and Polish Branch Standards BN-90/1785-01 [3, 4]. Research results are shown in Figures 1–2.

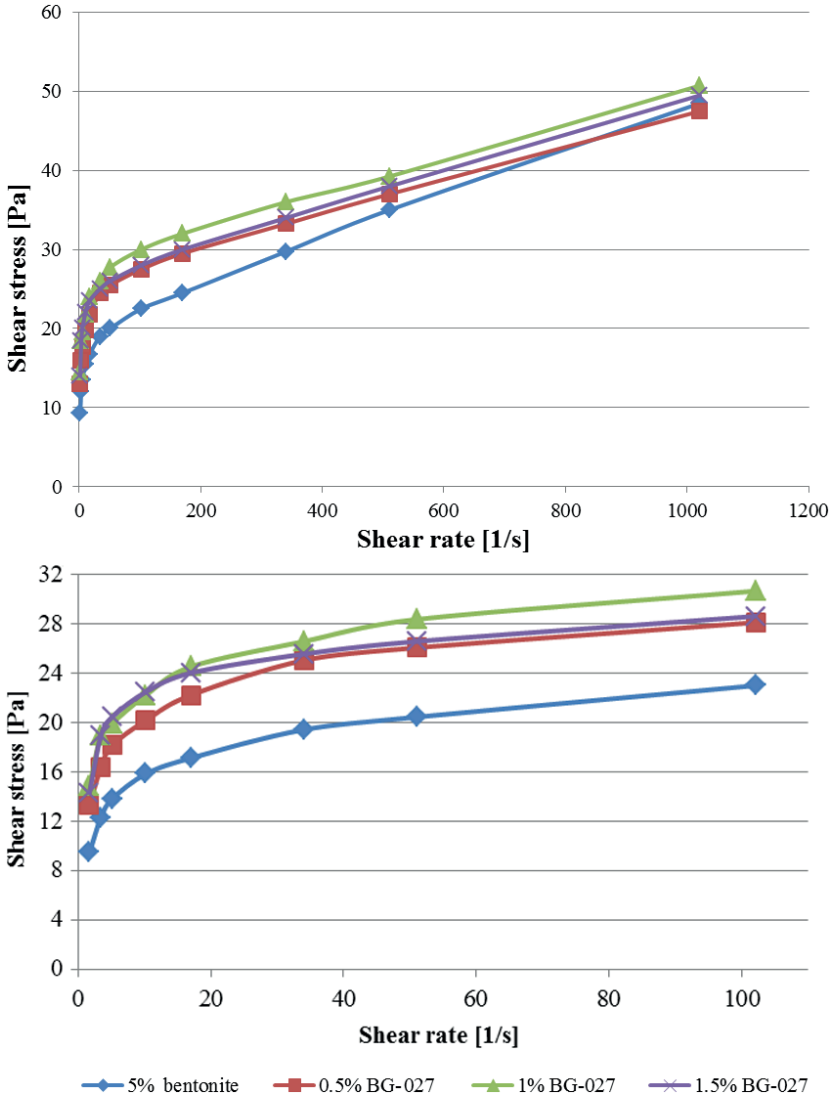


Fig. 2. BG-027 polymer concentration influence on the rheology of the bentonite suspension

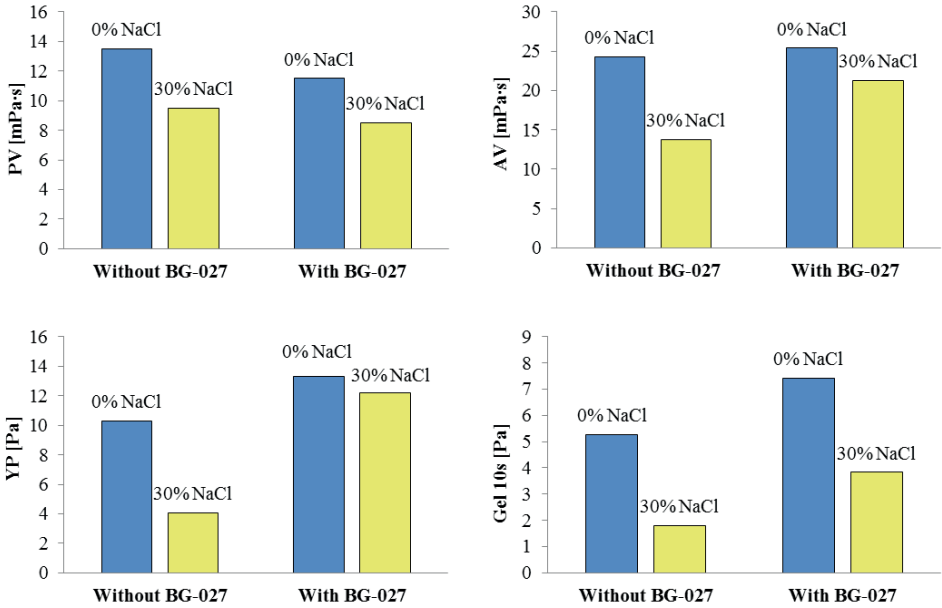
Figure 2 shows the results of measurements – the dependence of shear stress on shear rate. It has been found that already very small (0.5% by weight) BG-027 polymer additive causes a significant increase in the shear stress at low shear rates, compared to mud without

polymer. At the same time the value of stress at high shear rates do not undergo a change. It is a very positive result indicating that polymer BG-027 can be used as a component of muds dedicated to directional drilling. The best results have been noticed for 0.5% BG-027 polymer additive, and this concentration has been used in further studies.

The study showed that the BG-027 polymer additive causes a slight decrease in plastic viscosity of the mud. With an increase in the concentration of BG-027 is a slight increase in the value AV, YP, geles and reduction of filtration.

**Mono- and divalent salts contamination resistance**

During the drilling process we often encounter unforeseen obstacles like: salt water tributaries or inserts of salt formation. Both can be a source of mono- and divalent salts that have a significant impact on the parameters of the drilling fluid. A resistance test was conducted with the BG-027 polymer muds contaminated by these salts. The results are shown in Figures 3–4.



**Fig. 3.** NaCl contamination influence on mud parameters

The study showed that the suspension of the bentonite with the addition of BG-027 polymer has a high resistance to the monovalent salts appearance. Even the 30% addition of NaCl (salinity to saturation) did not cause significant changes in rheological parameters. A similar situation exists in the case of the contamination of divalent ions. Fluids containing polymer have a very good resistance to magnesium ions and only slightly lower to calcium ions.

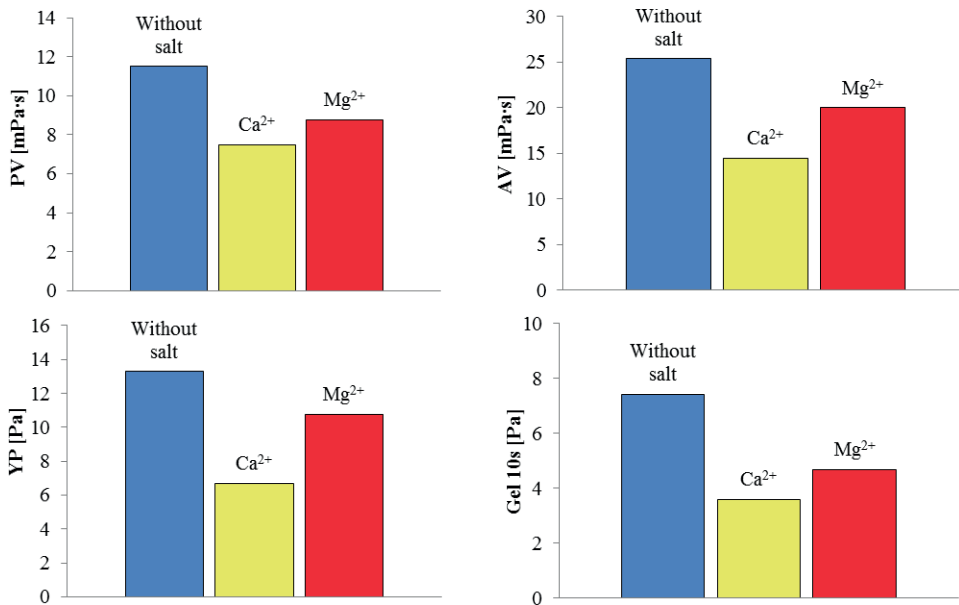


Fig. 4. Magnesium and calcium salts contamination influence on mud parameters

### Rheological model determination

Rheological model of the tested mud with 0.5% BG-027 was determined using Rheo-resolution 3 software, developed by the Department of Drilling and Geoengineering which is a part of the Faculty of Drilling, Oil and Gas AGH University of Science and Technology. The results are shown in Figure 5.

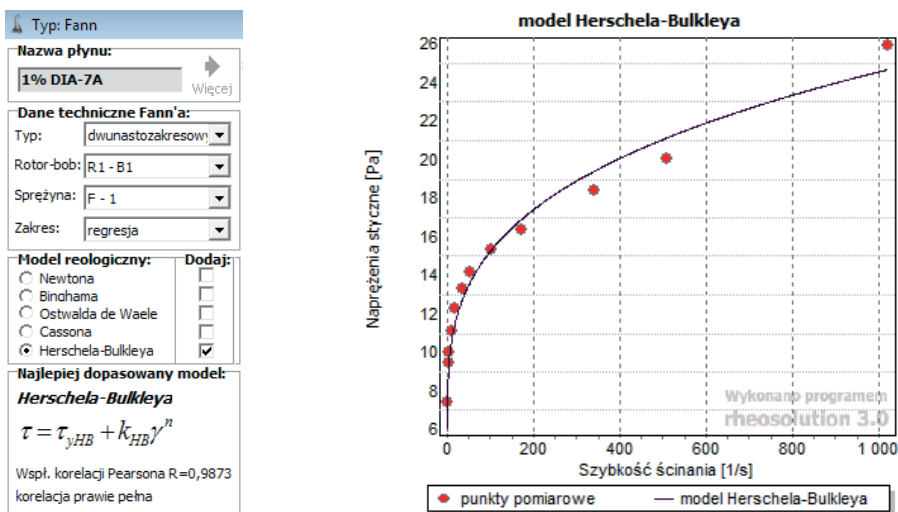


Fig. 5. Rheological model of the tested mud

Mud with the addition of BG-027 meets the assumptions of the Herschel–Bulkley model. The Pearson correlation coefficient is 0.9873. A description using the Bingham model used by industry standards proved to be less accurate.

**Thermal resistance of the BG-027 polymer**

In order to check the thermal resistance of mud, composed of 5% bentonite suspension and 1% of the polymer BG-027, rheological parameters in different temperatures have been tested by using a FANN viscometer with a heating cup. The results are shown in Figure 6.

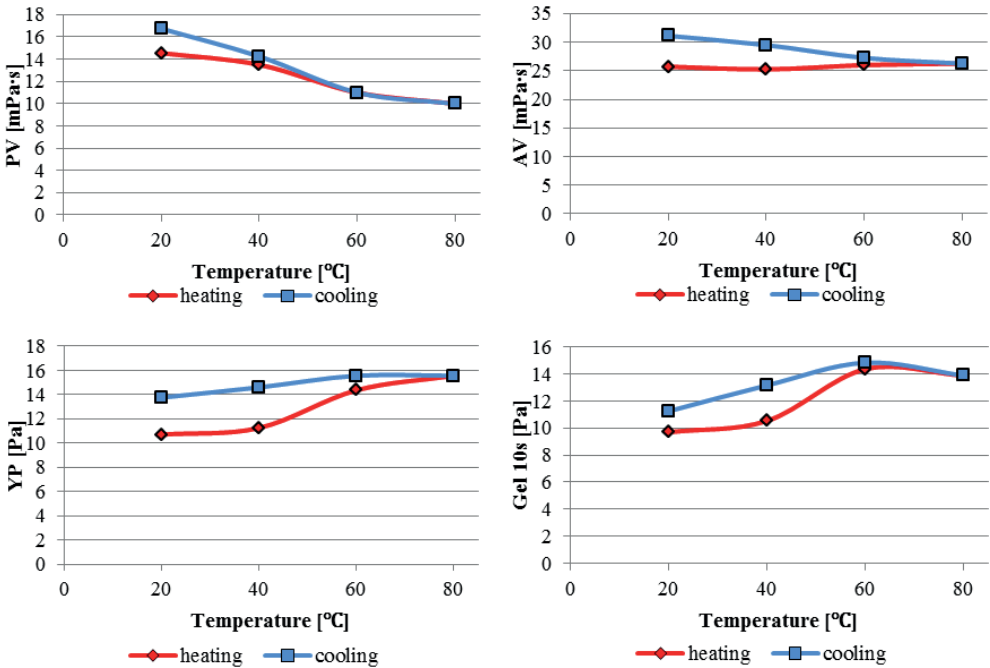


Fig. 6. Thermal resistance of mud with BG-027 polymer

A study involving the heating and cooling mud. Results show that despite temperature changes in the range of 20–80°C, the rheological parameters are not substantially changed. This indicates its good temperature resistance.

**Linear Swell Test**

A Linera Swelling Test has been conducted for mud with 0.5% BG-027 polymer addition. The test was conducted using HPHT Linera Swell Meter by 20 hours for a sample of eocene shale. The results are shown in Figure 7.

The research showed that the mud with BG-027 polymer addition has good hydration inhibition properties. The swelling of eocene shale after 20 hours is about 6.5% only.

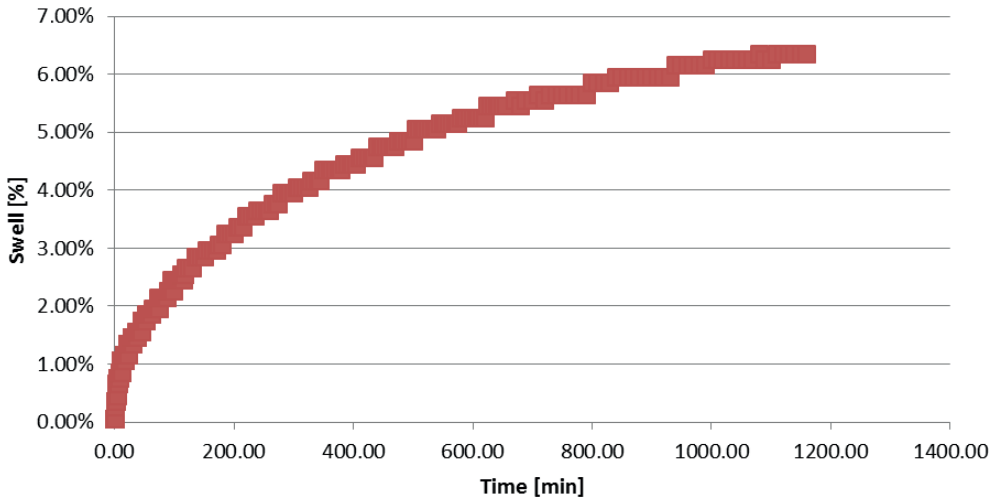


Fig. 7. Results of Linear Swelling Test for composed mud with BG-027 polymer

### 3. CONCLUSIONS

Based on the performed research it was found that the polymer BG-027:

- Meets the requirements for drilling fluids dedicated to directional drilling: effectively increases the rheological parameters of mud at low shear rates.
- is resistant to contamination of mono- and divalent ions,
- can be used in muds based on brine,
- is immune to increased temperature which may appear during deep drilling,
- is a good swelling inhibitor

For economic reasons, the additional advantage is the fact that the polymer BG-027 is effective at low concentrations (approx. 0.5% by weight). A simple recipe of muds with the polymer addition guarantees relatively easy adjusting the process parameters. Further research is planned over the polymer BG-027 and its modifications.

### REFERENCES

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