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The Rheology of Polymer Dispersions and the Effect of Crude Oil Contamination

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Abstract

When opening the productive strata and as completion fluids, the polymer solutions are frequently used. In this paper, a rheological study was performed on solutions of Xanthan gum of different particle sizes and at two different concentrations.

In addition, it has been analyzed the rheological behavior after contamination in different percentages, from slight to heavy levels of contamination.

Key words: *polymer solution, rheology, crude oil contamination*

Introduction

The most modern drilling fluids that are used to open the productive strata are prepared as polymeric dispersions which manage to fulfill the needed requirements for this type of usage [1, 2]. One primer additive for these systems is the rheology controlling agent and in this study the authors chose to work with a common viscosifier, the Xanthan gum.

The study focuses on the flowing behavior of aqueous dispersion of Xanthan gum [3], considering the scenarios of crude oil contamination, very probable when crossing productive strata [2]. A gradual level of contamination, from slight (10%wt) to heavy (50%wt) was taken into account.

In addition, three different degrees of Xanthan gum particle fineness were used at polymeric dispersion preparation in order to observe if any role is played by this aspect at maintaining the rheological features during crude oil contamination.

The practical and technological goal is to have feasible, flexible and economical recipes for drilling fluids, even in the worst case scenario of usage. Maintaining the flowing characteristics is of utmost importance when dealing with drilling fluid circulation into the wellbore [4].

Experimental

The materials used were Xanthan gum of 98% purity from Chemopar S.A. and a sample of crude oil taken from Moreni production field, with a density of 0.815 kg/m^3.

The Xanthan gum was brought to finer particle sizes by manual grinding in an agate bowl and with an agate pistil and by automatic grinding with a Fritsch Pulverisette mill with agate bowl and 20 agate balls of 20 mm diameter. The latter procedure took 8 hours to do and it was carried under permanent stirring.

The granulometric analysis of the Xanthan gum was performed by the dynamic light scattering technique (DLS) with the equipment Nano ZS (Red Badge).

The polymeric dispersions were prepared by continuous stirring with a mixer for 30 minutes at 1000 rpm and the polymer additive was added gradually into the water. The final dispersion had a concentration of 0.5% wt and 1%wt Xanthan gum. The crude oil was poured directly into the mixture and let to interact for 30 minutes under continuous stirring.

The rheological measurements were performed with a PVS Brookfield rheometer and analyzed using its software interface, Rheovision.

Results and discussions

The Xanthan gum was ground and characterized by the particle size distribution curve. Besides the initial granulometric characteristics (fig. 1), another two finer varieties were obtained (fig. 2, 3).

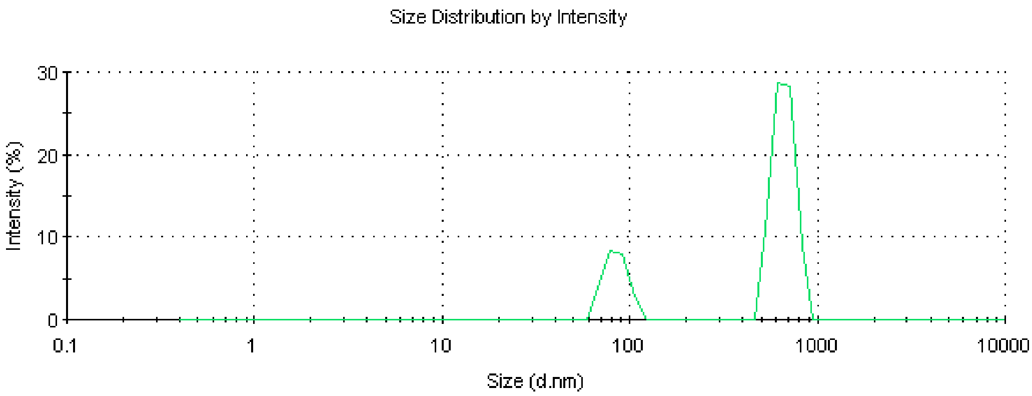

Fig. 1. The size distribution curves of the brutish Xanthan gum.

It can be observed a peak of 23% intensity of 84.5 nm and another peak of 77% intensity at 664 nm.

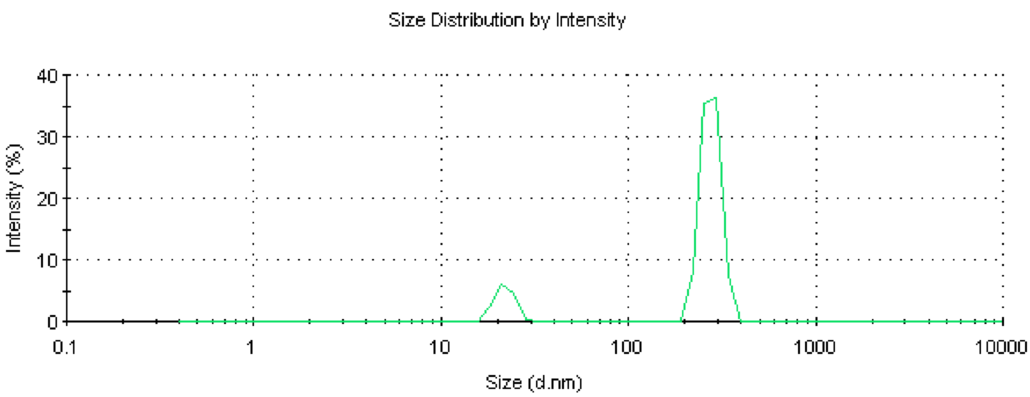

Fig. 2. The size distribution curves of the medium size Xanthan gum.

A first peak of 13% intensity is present having a medium size of almost 22nm and a second peak of 87% intensity has a medium particle size of 276nm.

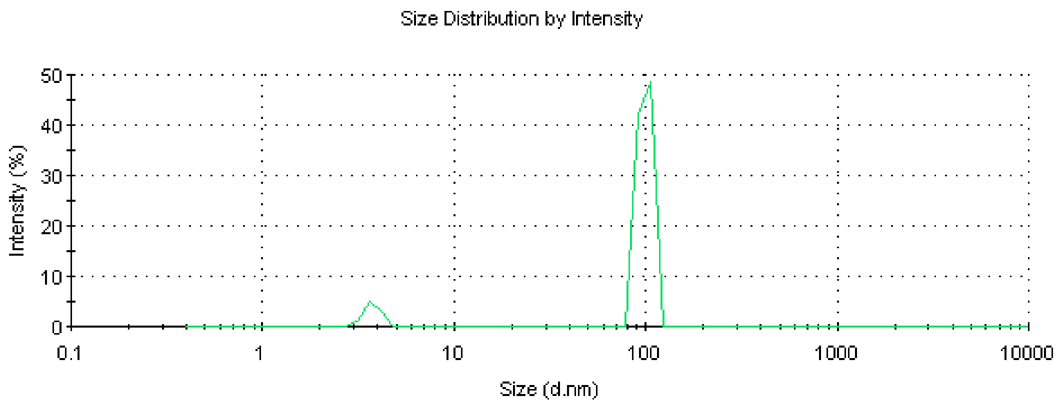

Fig. 3. The size distribution curves for the finest Xanthan gum.

The majority of the particle population (91%) have an average size of 99nm, while the rest of 9% are smaller, having around 3.7nm.

The first rheological measurements were meant to underline the rheological model to which these polymeric dispersions fit. Figures 4 and 5 show experimental rheograms compared by the Rheovision software with the theoretical model curve fitted.

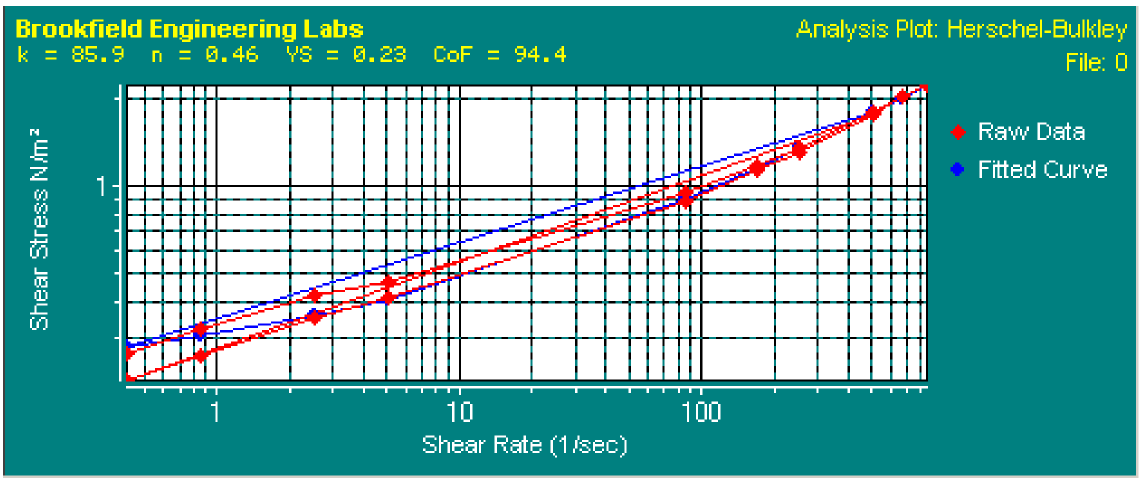

Fig. 4. The fitted and the experimental flow curves of an aqueous dispersion of fine Xanthan gum

It can easily be seen that a high confidence fit of the experimental data (94.4%) is given by the Herschel – Bulkley model [4].

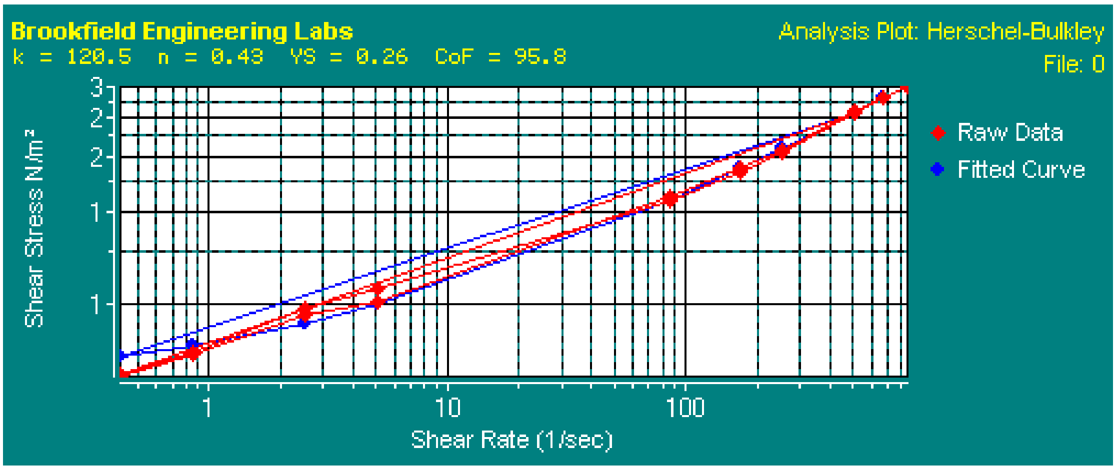

Fig. 5. The fitted and the experimental flow curves of an aqueous dispersion of fine Xanthan gum contaminated with 50%wt crude oil.

As well as the anterior case, the heavily contaminated system maintains its flow behavior, as the experimental data fits XX% to the same Herschel –Bulkley model.

The next step was to study the influence of the Xanthan gum concentration (fig. 6, 7) and of the Xanthan gum particle size (fig. 7, 8) on the flowing pattern.

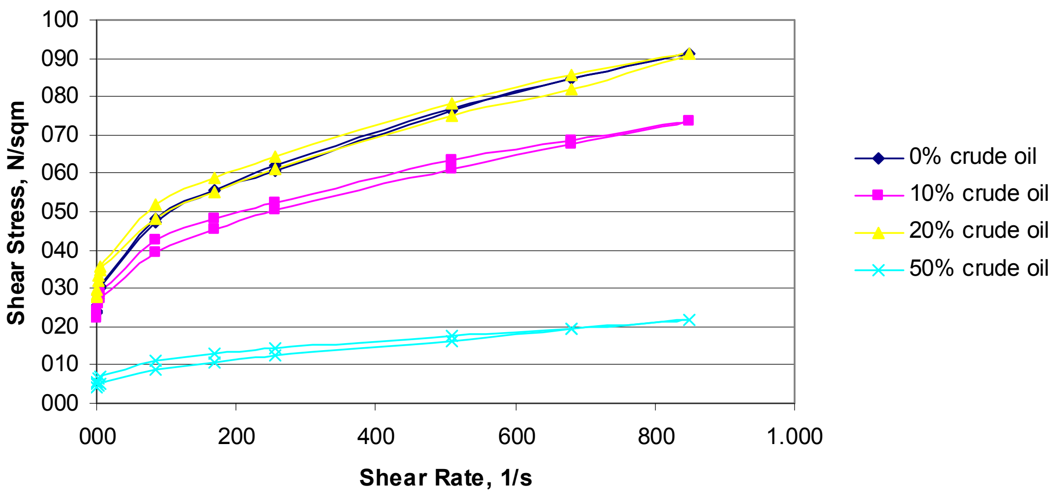

Fig. 6. The flow curves for 1% brutish Xanthan gum aqueous dispersion contaminated with crude oil.

Though the values of the shear stress are higher in the case of 1% gum concentration, the systems with 0.5% Xanthan provide fair rheological features under more economic circumstances. The less concentrated system is even more resistant at crude oil contaminations; the variations of the flow curves are less intense.

The stability of the system increases when the granulation of the Xanthan gum is finer at 0.5%wt concentrations.

Another aspect concerns the evolution of rheological behavior of the polymeric dispersions in two different concentrations at a slight contamination with crude oil (fig. 9) and at a heavy contamination (fig. 10).

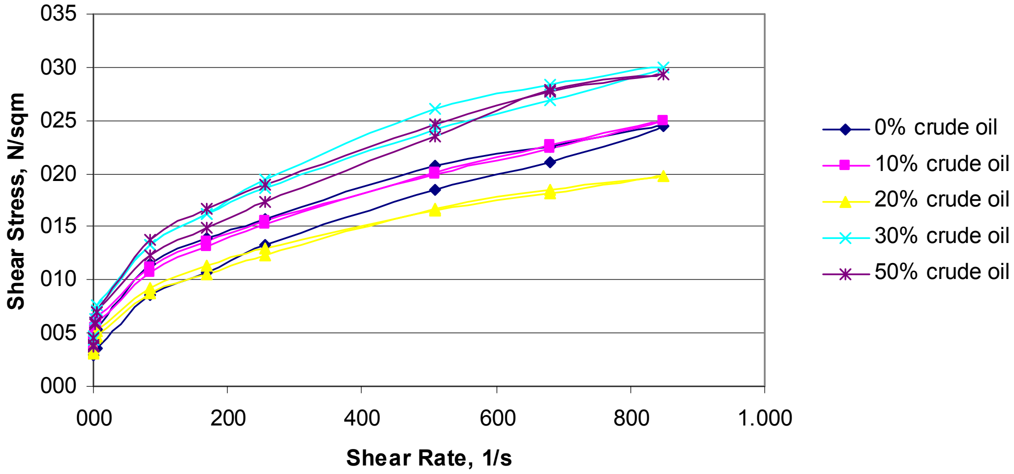

Fig. 7. The flow curves for 0.5% brutish Xanthan gum aqueous dispersion contaminated with crude oil.

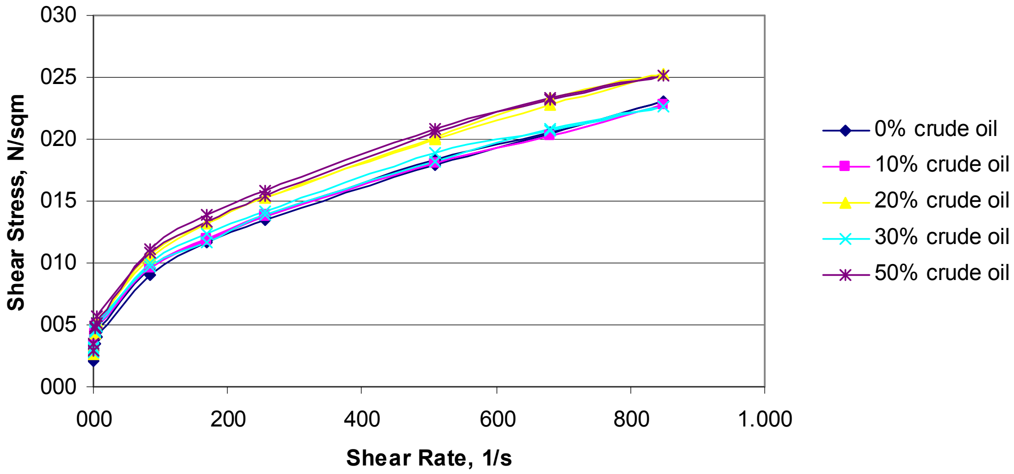

Fig. 8. The flow curves for 0.5% fine Xanthan gum aqueous dispersion contaminated with crude oil.

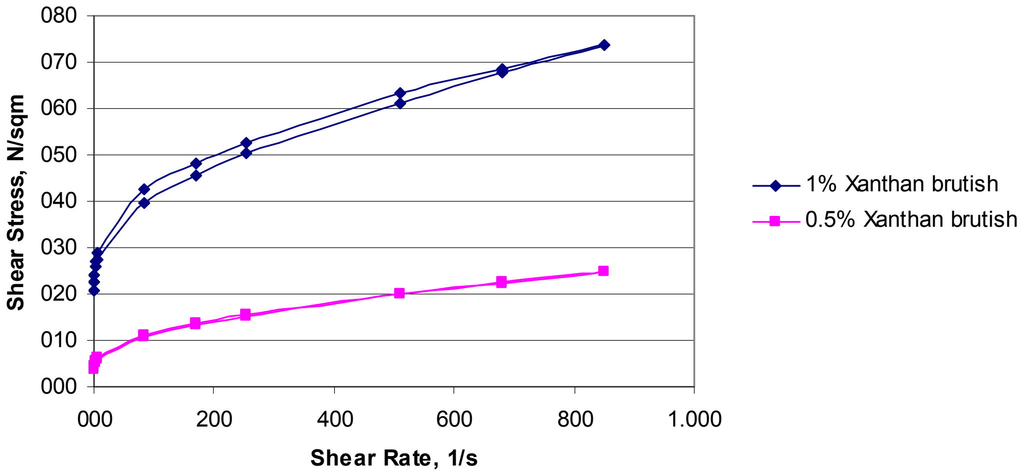

Fig. 9. The comparison of flow curves at different Xanthan gum concentrations at 10% crude oil contamination.

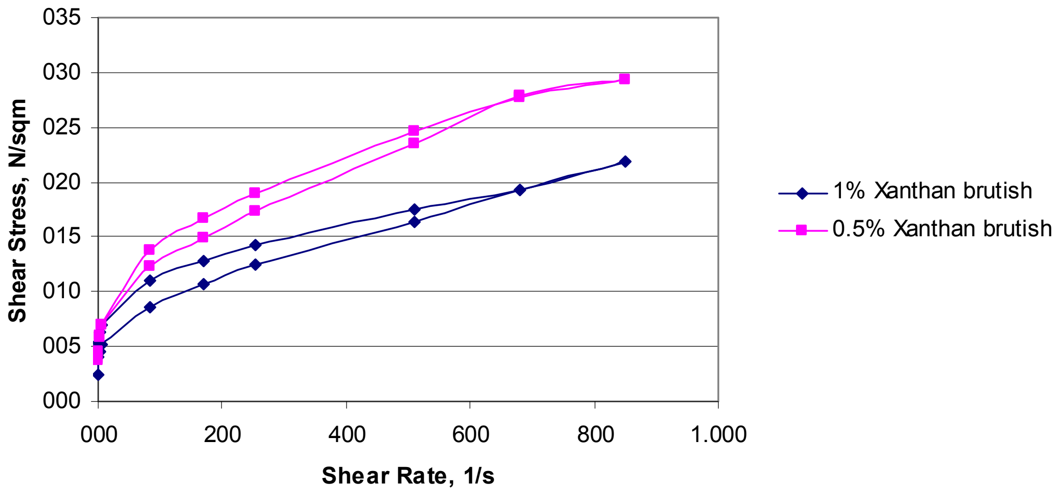

Fig. 10. The comparison of flow curves at different Xanthan gum concentrations at 50% crude oil contamination.

There is a reverse type of response of the systems during crude oil contamination depending on the Xanthan gum concentration. More viscosifier can take well low amounts of crude oil, while less Xanthan gum systems behave better when contaminated heavily.

Finally, it was studied the influence of Xanthan gum particle size on the flowing behavior at light crude oil contamination (fig. 11) and at heavy crude oil contamination (fig. 12).

The dispersed systems with 0.5%wt Xanthan gum contaminated with crude oil, both slightly or heavily, are not significantly altered by this aspect, regardless of the viscosifier granulation.

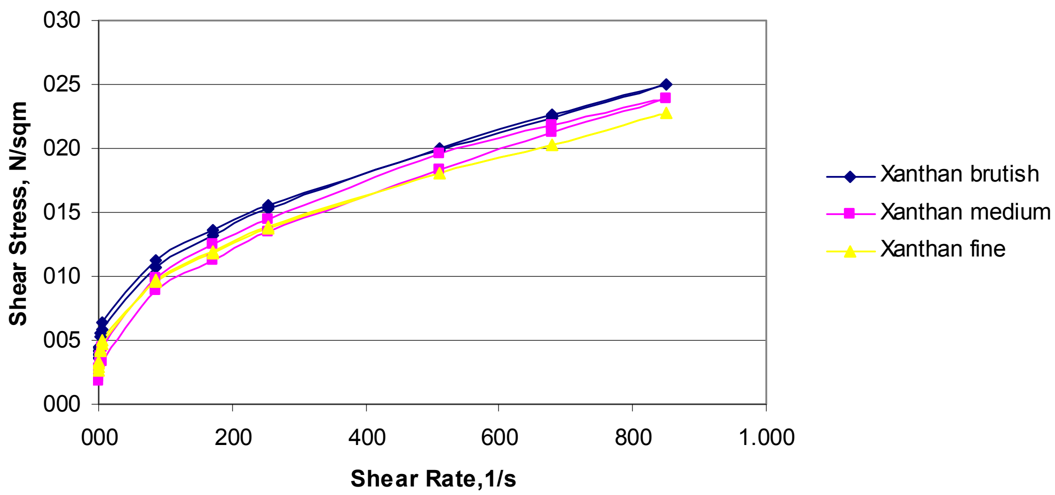

Fig. 11. The comparison of flow curves at different Xanthan gum granulation at 10% crude oil contamination.

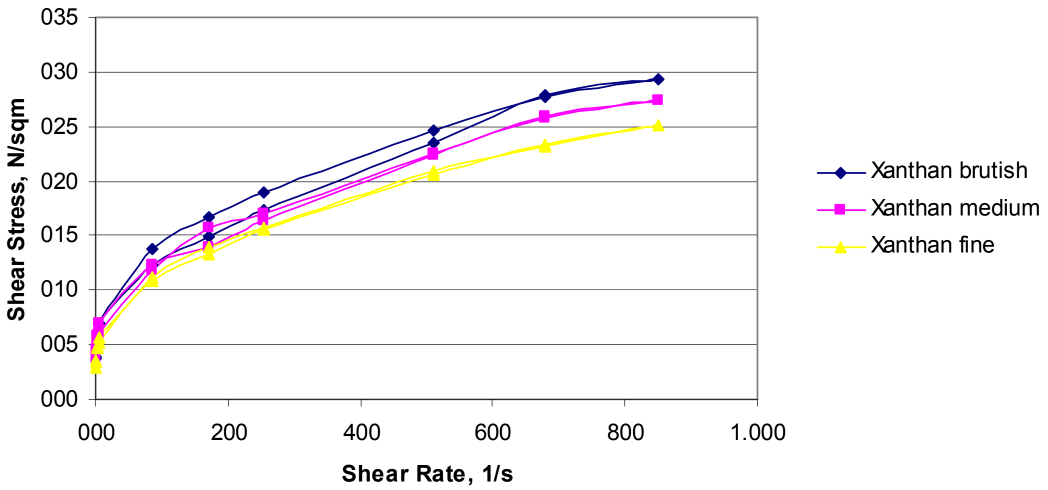

Fig. 12. The comparison of flow curves at different Xanthan gum granulation at 50% crude oil contamination.

Conclusions

The presented study is providing a sound understanding on the flowing behavior of polymeric dispersions used as drilling fluids to open productive strata and its main ideas are as follows:

- The rheological model that best describes these systems behavior is Herschel – Bulkley, remaining the same even in the case on heavy crude oil contamination;
- The comparative studies are in favor of using lower concentrations of Xanthan gum, in finer granulometric distribution;
- In heavy contamination scenarios, the dispersed systems with 0.5% wt Xanthan gum are more stable and maintain their rheological properties better than the ones with 1%wt Xanthan gum;
- At low concentration of Xanthan gum, the aqueous dispersed systems are not considerably affected by the granulation degree of the polymer, thus maintaining good rheological properties.

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Reologia dispersiilor de polimeri şi efectul contaminării cu ţiţei

Rezumat

La deschiderea stratelor productive şi ca fluide de completare, se folosesc deseori dispersii de polimeri. În această lucrare s-a efectuat un studiu reologic pe dispersii apoase de gumă de Xanthan cu diferite dimensiuni de particule şi la două concentraţii.
În plus, s-a analizat comportamentul reologic după contaminare în diferite proporţii, de la contaminare la nivel uşor până la nivel puternic.