Short Communication
Insights in Analytical Electrochemistry
2020
Vol. 6, Iss. 1

Rheological Properties of Polyethylene Glycol Solutions and Gels

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It is indicated that under characterized conditions gel is framed in the glycol from the glycol recovery plants, which made huge operational issues. The consequences of lab research on the creation of gels from polyethylene glycol water and water-glycol arrangements just as investigation of rheological properties of these gels and

polyethylene glycol arrangements are given. It is indicated that after surpassing the specific shear rate esteem gels exhibit strange rheological property (moment stream end).

Keywords: Oil and gas production; Glycol regeneration; Polyethylene glycol (PEG); Gel; Shear stress

Introduction

Monoethylene glycol (MEG) is generally applied in oil and gas creation. One of utilizations is counteraction of hydrates [1,2]. There is probability of hydrates development in multiphase pipeline during gas and condensate transportation from LUN-A seaward stage to Onshore

Procedure Facility (OPF) of Sakhalin-2 Project. To forestall hydrates the stage infuses MEG water arrangement into pipeline at grouping of 85 mass%. OPF isolates and recovers MEG. Recovered MEG comes back to stage by means of committed pipeline. OPF MEG recovery process schematic is appeared on Figure 1.

Preceding recovery rich MEG is taken care of into two-stage separator to evacuate gas and expel solids on MEG channel. At that point MEG is warmed up in the reflux condenser by fume to 75°c and in lean MEG/rich

MEG heat exchanger to 100°c. At that point MEG arrangement comes to reboilerwhere water in glycol is dissipated to the necessary centralization of glycol. MEG arrangement in reboiler is warmed up to 126°c at environmental pressure. Working temperature of warming component surface in reboileris 170°c, most extreme temperature (without chilling off by MEG arrangement) - 210°c. Recovered MEG is chilled off utilizing air coolers also, siphoned to capacity tank (not appeared on Figure 1) for resulting gracefully to seaward stage.

In April 2011, during routine activity of OPF MEG recovery unit quick development of weight differential across lean MEG siphon pull sifter was watched. Cleaning of sifter demonstrated that it was totally secured with green gel stores. Sifter stopping up endured for a few days (sifter must be cleaned each 1.5-3 hours), at that point abruptly halted [3].

Examinations of potential reasons of gel development distinguished: gel development began after well from Lunskoye oil edge area was put in activity saltiness of delivered water from this all around was ~ 16 g/dm3 , particles over the creation time of the well sharp increment of grouping of broke up salts in MEG arrangement (from 750 mg/dm3 to ~ 1350 mg/dm3) and grouping of calcium particles were watched green shade of gel implies incorporation of Fe2+ particles into gel creation, grouping of Fe2+ particles in MEG arrangement has not changed being ~ 10 mg/dm3it was discovered that MEG arrangement at OPF MEG recovery framework

contains polyethylene glycol (PEG) at fixations up to 480 mg/ dm3 at normal molar load of 5500 Da gel development halted after shutdown of the oil edge well

Worth to specify that gel in glycol recovery frameworks was additionally saw at different fields - specifically NAM L9 stages in the North Sea (MEG recovery

framework), Bacton Gas Terminal

in the North Sea (MEG recovery framework) and Menza Project in Gulf of Mexico (TEG recovery framework) [3,4]. Prior creators demonstrated that gel arrangement in glycol recovery frameworks happens because of PEG age in such frameworks [5-7] with resulting crosslinking with calcium or iron particles [3,4]. It is known [8-12] that PEG in little fixations (under 0.1 mass %) has no huge impact on consistency of glycol arrangement. In this manner, PEG age can notbe a sensible reason for depicted above procedure disappointments. Clearly under specific conditions PEG gel development happens coming about in sudden increment of MEG thickness.

To affirm this speculation research facility tests were performed to plan PEG gels and to consider their rheological properties.

Trial

To get ready gel from MEG water arrangement 20.0 g of PEG of 4000 Da molar weight was broken down in 50 vol. % MEG arrangement, 14.6 g of CaCl2 .2H2 O was added and weakened to 100 cm3 . Centralization of PEG established 0.05 mol/dm3 , calcium fixation - 1.00 mol/dm3

Arrangement in a fixed glass bottle was warmed in drying broiler at 120°c. Gel was seen following 1 hour of warming (Gel 1).

To get ready gel from water arrangement 20 g of PEG of molar weight 4000 Da was broken down in refined water, 21.9 g of CaCl2 .2H2 O was added and weakened to 100 cm3 Centralization of PEG comprised

0.05 mol/dm3

, calcium-1.5 mol/dm3

. Arrangement in a fixed glass bottle was warmed in drying stove at 120°c. Gel was seen following 1 hour of warming (Gel 2).

Rheological properties of PEG arrangements and gels were contemplated utilizing AAKE VT-550 viscosimeter with MV-1 sensor. Reliance of shear stress and dynamic consistency on shear rate (γ) was investigated in test.

Results and Discussion

We have established that PEG gels below certain values of γ behave as Newtonian fluid. However, when shear rate exceeds a certain value, which depends on gel viscosity, gels show abnormal property - instant flow cessation (full stop of spindle rotor) that is inherent to dilatant liquids during sharp increase of viscosity. Figure 2 shows dependence of shear stress and dynamic viscosity of Gel 1 on γ at 25°C. Below γ ≈ 1000 c-1 gel behaves as Newtonian fluid - shear stress is linearly increasing with increasing of γ, viscosity is constant being 126.2 ± 1.8 mPa·s. At γ=1032 s-1 and in the interval of 1326 ≤ γ ≤ 1479 s-1 instant flow cessation and total stop of spindle rotor occurs. With further increasing of γ shear stress and viscosity fall notably. We assume that at certain shear rate the structure of gel partially breaks causing sharp reduction of gel viscosity. Nonetheless further tests of the same gel showed that dependence of shear stress and viscosity on γ is not changing and the flow cessation occurs at the same values of γ; i.e., if gel structure is broken it is restoring over a short period of time after shear stress removal. When temperature increased to 60°C viscosity of Gel 1 drops to 31.91 ± 0.75 mPa·s, cessation of flow does not occur till γ=1872 s-1. Figure 3 shows dependence of shear stress and dynamic viscosity of Gel 2 on γ. Below γ ≈ 70 s-1 Gel 2 behaves as Newtonian fluid, viscosity is 865.0 ± 9.0 mPa·s. With γ increasing viscosity increases sharply and at γ ≥ 170-1 75 s-1 instant flow cessation occurs.

Data from Figure 3 allow concluding that PEG gels are dilatant liquids when γ reaches certain values. At 60°C viscosity of Gel 2 is slightly increasing (by ~ 7%) with increasing of γ being (average value in the interval of 0<γ<γ

Abnormal property of PEG gels, namely instant flow cessation when shear rate exceeds a certain value is of practical importance for operation of glycol regeneration units. At low shear rates (below critical

γ values) observed in pipelines and vessels viscosity of gel is not high and is not affecting operation of regeneration system. With sharp increase of shear rate (e.g., when gel passing through fine pores of filters) sharp increase of viscosity occurs resulting in clogging of filters. Slowdown or stoppage of flow removes shear rate and viscosity of gel returns to initial value thus resuming the flow. However, when shear rate increases again described above reoccurs. Thus, presence of gel with abnormal rheological property in the glycol regeneration systems may cause filters clogging if critical shear rate would be reached. Water solutions of PEG are also dilatant liquids. Figure 5 shows dependence of shear stress and dynamic viscosity of 15 mass % PEG solution with molar weight 4000 Da on γ at 25-28°C. When γ changes from 0 to 1700 s-1 viscosity increases from 4.6 to 8.8 mPa·s. Similar values were obtained for other PEG solutions. Thus, viscosity of 1 mass % of PEG with molar weight 6000 Da water solution at same conditions increases from 2.4 to 3.9 mPa·s. MEG water solutions behave as Newtonian liquids when γ ranges from 0 to 1872 s-1. Figure 6 shows dependence of shear stress and dynamic viscosity of 85 vol. % MEG water solution on γ at 25-28°C. Shear stress is linearly increasing with increasing of γ, viscosity is constant being 10.8 ± 0.9 mPa·s.

Synopsis and Conclusion

PEG gels up to certain shear rates carry on as Newtonian fluids.

In any case, on surpassing certain shear rate esteem that is subject to the gel thickness moment stream suspension happens. PEG gels thickness is essentially decreased with temperature increment.

Thickness of gel increment exponentially with expanding of convergence of cross-connecting metal at consistent centralization of PEG. In this manner to decrease thickness of gel it is important to control convergence of calcium and iron particles in water-glycol arrangements of glycol recovery units.

Thickness of gels is straightly expanding with expanding of focus of cross-connecting metal at consistent convergence of PEG.

PEG gels are dissolvable in water-glycol arrangements essentially expanding their thickness.

Unusual rheological property of PEG gels (moment stream suspension on surpassing certain shear rate esteem) may mess up activity of glycol recovery units.

To forestall gel arrangement in the glycol recovery frameworks administrators will create and execute a glycol quality control system with center around observing of convergence of PEG, calcium, what's more, iron particles. Suggested glycol quality control boundaries are created in ref. [7].