View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Tomsk State University Repository

ISSN 1070-4272, Russian Journal of Applied Chemistry, 2015, Vol. 88, No. 1, pp. 118−123. © Pleiades Publishing, Ltd., 2015.
Original Russian Text © V.N. Manzhai, Yu.R. Nosikova, A.V. Abdusalyamov, 2015, published in Zhurnal Prikladnoi Khimii, 2015, Vol. 88, No. 1, pp. 124−130.

Degradation of Polymer Solutions in a Turbulent Flow in a Cylindrical Channel

V. N. Manzhai[a,b], Yu. R. Nosikova[a], and A. V. Abdusalyamov[c]

[a] *Institute of Petroleum Chemistry, Siberian Branch, Russian Academy of Sciences, Akademicheskii pr. 3, Tomsk, 634021 Russia*
[b] *National Research Tomsk Polytechnic University, pr. Lenina 30, Tomsk, 634050 Russia*
[c] *National Research Tomsk State University, pr. Lenina 36, Tomsk, 634050 Russia*
e-mail: mang@ipc.tsc.ru

Received December 24, 2014

Abstract—Water- and oil-soluble polymers capable to reduce the turbulent flow drag were studied. The cause of a decrease in the Toms effect under various conditions was determined. Recommendations were formulated for optimum use of the polymers in pipeline transport technologies.

DOI: 10.1134/S1070427215010176

The phenomenon of drag reduction (Toms effect) has found wide use in power-saving technologies for pipeline transport of liquids [1–6]. However, already early studies of the drag reduction effect revealed instability of polymer solutions in a shear rate field [7, 8]. This instability is often attributed to the degradation of macromolecules. The degradation leading to cleavage of covalent bonds in the polymer backbone and to a decrease in the molecular mass can be caused by different factors: heating of the solution or mechanical action in the course of its stirring, passing through sites of local resistance in pipeline networks or through pipe segments with longitudinal extension [9], action of oxidants, etc. It is also noted [7] that the capability of a polymer solution for drag reduction gradually decreases with the distance of flow in the pipe or with an increase in the number of passages through a cylindrical channel in an open installation. The degradation intensity increases with an increase in the shear stress on the pipe wall, and upon passage through pump stations of long-distance main pipelines the performance of antiturbulent additives decreases virtually to zero [6]. Today, there is also another, less widespread viewpoint concerning instability of polymer solutions. Makogon et al. [10] attributed the observed decrease in the effect not to a decrease in the molecular mass of the polymer due to polymer chain break but to degradation of polymer solutions, without explaining the physicochemical sense of this term.

The problem of mechanical degradation of macromolecules in a turbulent flow of polymer solutions seriously complicates efficient use of antiturbulent additives in pumping of liquids along main pipelines. Such pipelines are operated, as a rule, at very high Reynolds numbers (Re ~ 1×10^4–1×10^6) and relatively low shear stresses on pipe walls (τ_w ~ 1–10 Pa).

This study was aimed at revealing the cause of the decrease in the Toms effect under various conditions and at formulating recommendations for optimum use of polymers in pipeline transport technologies.

EXPERIMENTAL

As investigation objects we used both water- and oil-soluble polymer samples. Hydrodynamic tests of the solvents and polymer solutions were performed on a turbulent rheometer, which was simple in design and similar to a capillary viscometer, but allowed hydrodynamic studies to be performed under the conditions of both laminar and turbulent liquid flow. The turborheometer, which is an open-type installation, is described in [3, 11, 12]. As found in experiments [7], on introducing a high-molecular-mass polymer into