

959. Mathematical modeling of oil transportation by pipelines using anti-turbulent additives

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Abstract. The energy costs of oil transportation by pipeline are one of the most important questions for oil companies. Large amounts of energy are used in the oil pumping process. One of the ways to reduce energy costs is to use additives, which can change the rheological characteristics of oil. Anti-turbulent polymer additives reduce the hydraulic resistance and allow a significant reduction in pumping costs. The hydrodynamic processes in the pipeline and efficiency of oil transportation costs, dependent on the concentration of anti-turbulent additives, are investigated in this paper. The pressure and velocity of the flow in each point of the pipeline are obtained by solving a system of nonlinear algebraic equations, which were solved utilizing the Newton-Raphson method. The dependencies of the efficiency coefficient in the oil pumping process were deduced, depending on the concentration of the additives.

Keywords: oil transportation, additives, numerical method.

1. Introduction

Oil transportation by pipeline requires a lot of energy. The load is constantly changing in the oil pump motors and consumes vast quantities of electricity. The optimization of oil pumping regimes increases the oil throughput and electric motor efficiency.

Sections of the oil pipeline in which inner sand, wax or tar aggregations have formed are a major contributor to increased energy consumption.

This problem is important when transporting high viscosity, heavy and extra-heavy crude oil. Innovative technological solutions concerned with viscosity and friction reduction to move such crude oils from the production site to the processing facilities are presented in the work [1]. The stability and viscosity of water-oil emulsions and their application for heavy oil pipeline transportation were investigated in the work [2]. Factors affecting the properties and stability of these emulsions were investigated and were limited to 60 % for crude oil content in the emulsions. Different methods for reducing the viscosity of heavy crude oil to enhance the flow properties were investigated in the work [3]. The influence of shear rate, temperature and light oil concentration on the viscosity behavior was studied. It was observed that the blending of heavy crude oil with a limited amount of lighter crude oil provides better performance than the other alternatives.

One of ways to improve the process of oil transportation is to use a reagent, which modifies the paraffin wax properties in a way so that it does not adhere to the pipe walls. The usage of anti-turbulent polymer additives, which reduce the hydraulic resistance in oil during its flow, allows a significant reduction in pumping costs [4]. The additives are substances which reduce the hydraulic resistance and increase the throughput of the oil pipeline [5]. Some of the additives are high molecular weight polymers. The polymer additives increase the flow rate at a constant pressure [6]. The most widely used additives are polymers such as polybutadiene, polyisoprene, polystyrene, its derivatives and others.

The object under investigation in the paper [7] was the reduction of the turbulent friction