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ScienceDirect

Procedia Engineering 152 (2016) 158 – 162

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

The innovative design of the disperser for separating particles of oil

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Abstract

A process of separating particles have been of major importance in many industries, including oil and gas engineering industry due to its application in pipeline system in which the viscous fluid flows. The entry into new technology areas in application to particles around a micro- nanoscale and smaller imposes an exclusive requirement for devices and techniques for the transportation of viscous fluid through pipelines. Due to the requirements to prevent the particle coarsening and formation agglomeration, the potential for a range of novel research opportunities is emerged. This paper presents an innovative separation device designed by authors, which uses the change of the energy of the particles to achieve separation of a mixture of oil particles. Furthermore, we investigate the impact of the parameters of the dispersers to its stability, and we put forward in evidence that there are best (optimum) parameters leading to better stability of the particle stream.

Peer-review under responsibility of the Omsk State Technical University

Keywords: model; stability; separator; oil; viscous flow; pipeline

1. Introduction

Today's petrochemical and oil&gas engineering industry, as well as monitoring, diagnostics, and automated control capabilities are the sophisticated multidisciplinary scientific and technical environment integrating the basic theory of oscillations, the theoretical and applied mechanics, the science of machines and many other areas. One of the main criteria for technological process in these industries is to remain homogeneous structure of fluid and granular stream [1–18].

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Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.648

In recent years it has become evident that an existing technology should be studied in a new light accounting new developing priority areas focused on micro- and nanotechnology. Such trend generates, from a material point of view, an exclusive requirement for uniformity of particle size, delivery systems and transportation techniques of the viscous and granular medium, micro- and nano-materials [2–5, 8–24]. During the transportation of crude oils and oil products by pipeline there is a strong trend for cluster aggregation due to the particle coarsening and entanglement in flow [9–18, 24], that is particularly true for heavy and highly viscous crude oil. This phenomenon can obstruct the flow caused by viscosity growth.

The maintenance and reduction of the dynamic viscosity when the homogenous flow moves in the pipeline is the focus of many practical applications. Due to particular attention to this problem, there is a need to formulate an effective and reliable devices and techniques to reduce the dynamic viscosity in particulate flow [19–24] to prevent the particle coarsening and formation agglomeration.

The desire to obtain a more satisfactory solution to the problem of particle coarsening and formation agglomeration during the transportation of viscous fluid through pipelines motivates us to create a new innovative device. This invention relates to apparatus and methods for reducing the viscosity of crude oil in order to facilitate transporting the oil.

2. Separator arrangement

It should be mentioned that the operating principle of the separator relies on the energy change of the particle free motion in dispersed flow was observed in [23–24]. The impact action, based on the aerodynamic dispersion of the particles in viscous medium in the separator leads to a smaller number of particle aggregates with decrease in particle size [18, 21–22] compared to the ordinary flow parameters. To evaluate the efficiency of the separator we performed experiments at a special maintenance & testing unit in small volumes of viscous fluid and we obtained a good effect. However, from an energy point of view, the energy-saving techniques for particle segregation should be used in real life. To meet these demands and to reduce energy requirement during the oil transportation by pipelines the best way is to use kinetic and potential energy of the particle stream while the original values of the dispersion and viscosity retain constant.

The proposed separator comprises the channel (jet), and the collision chamber including plug (spherical solid), which modify the continuous flow to shear flows in the pipeline. The spherical solid is mounted to the seat elastic nail, therefore along a symmetry axis of the viscous flow movement is defined. The kinetic and potential energy of the flow is used not only to impact action but also to increase the velocity of the viscous flow in flow cannel.

3. Methods

The idea is that the equilibrium state of the spherical solid after being subjected of the flow impact pressure determines the stability of the stream formation as a boundary layer in the flow channel. In order to illustrate this idea, we consider the stability analysis of the spherical solid.

3.1. Stability analysis of the separator

The theory of stability discussed by the A. Lyapunov, H. Poincaré, N. Zhukovsky and others is the fundamental basis for analysis not only of the mechanical systems and devices stability but the stability of the systems of any physical nature [20–27]. Lyapunov's methods for stability [25] is applied to find equilibrium solutions in any problems from those physical, economic or abstract mathematical systems which concern the behavior of different but "nearby" solutions to differential equation [26, 27]. According to the definition given by Lyapunov [25] the stability of the spherical solid as a system is based on linearizing near a point of equilibrium therewith it depends on the undisturbed motion [24], comparison function and start time (t=0). Whatever the system under investigation and the task assigned, one need to write equations of motion which will be used as model of the disperser operating.

We assume that there is an equilibrium state of the spherical solid–elastic nail system (S-NS), being Lyapunov system. The necessary and sufficient condition for the equilibrium state of the spherical solid with k degree of freedom and ideal constraint is the forces, applied to the spherical solid, equals zero $\{\mathbf{F}_i=0\}$ (i=1, 2,…,k) where i is