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ScienceDirect

Procedia Engineering 152 (2016) 247 – 250

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Oil and Gas Engineering, OGE-2016

Analysis of corrosion defects on oil pipeline surface using scanning electron microscopy and soil thionic and sulfate-reducing bacteria quantification

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Abstract

We completed an analysis of corrosion defects on oil pipeline surface by instrumentality of scanning electron microscopy and identified soil thionic and sulfate-reducing bacteria quantity. A surface of samples was studied by using of raster electron microscopy as a preparation for qualitative and quantitative analysis of elemental composition. Was identified a quantity of sulfate-reducing and thionic bacteria in a samples of soil contiguous to the surface of underground oil pipelines in the of Khanty-Mansiysk autonomous region territory (Ugra). A result of this research shows a significant oxidative activity, which accompanied an expressed corrosion process. Microbiological analysis of soil shows an existence of thionic bacteria and an absence of sulfate-reducing bacteria. Microorganisms existed in soil induces the corrosion of pipeline steel. Using of scanning electron microscopy in a combination with finding of quantitative specification of thionic and sulfate-reducing bacteria in soils allows to study the nature of corrosive surface of the oil pipelines and to evaluate an extension degree of biocorrosion in complex.

Peer-review under responsibility of the Omsk State Technical University

Keywords: biocorrosion activity of oil pipeline soil; scanning electron microscopy; sulfate-reducing bacteria; thiobacteria

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Peer-review under responsibility of the Omsk State Technical University
doi:10.1016/j.proeng.2016.07.698

1. Introduction

Corrosion processes on a surface of metals depends of physical- chemical conditions in a subsurface layer. An intensity of corrosion process is under influence of pH index, oxygen concentration, oxidative- reducing potential and chemical compounds concentration [1, 2]. Sulfate- reducing bacteria which responsible for 70- 80% of biodamage reduces sulfates existed in soil with an oxygen production used for cathodic depolarization process. Hydrogen sulfide decreases a hydrogen overstrain in acidic and acescent soil, eases a cathodic process passing. Sulfide- ions accelerates an anodic process [3]. All of this leads to corrosion current intensification and promotes a dissolution process acceleration. Thionic bacteria in their vital activity process forms an insoluble iron hydroxide film $(FeOH)_3$, which leads to differential aeration macrocorrosion pairs forming. It promotes a localization and metal dissolution process acceleration [4].

Goals of research were to conduct an analysis of oil pipeline corrosion defects using a scanning electron microscopy, to determine soil thionic and sulfate-reducing bacteria quantity.

2. Study subject

An ultimate examination of soil including scanning electron microscopy in combination with soil thionic and sulfate- reducing bacteria quantitative feature determination allows to study an oil pipelines corrosive surface and to evaluate a biocorrosion progress level. A pipe samples corrosive surface examination using the raster electron microscope JEOL JCM-5700 with energy dispersive spectrometer for realization of qualitative and quantitative elemental analysis allows to determine carbon and oxygen high quantity testifying significant oxidative activity during the corrosive process. Soil microbiological analysis showed thionic bacteria existence and an absence of sulfate- reducing bacteria. Received data are necessary for prevention of biocorrosion and for protection methods development.

3. Methods

As a preparation to research we took a samples of pipes clipped from an oil pipeline during maintenance works. Before the microscopic examination of pipeline steel samples they were subjected to eddy current control using eddy current flaw detector (VD-1) for corrosion sites diagnostics. A samples surface was studied by using a raster electron microscope JEOL JCM-5700 with energy dispersive spectrometer for qualitative and quantitative elemental composition analysis. We identified a sulfate-reducing and thionic bacteria quantity in soil samples contiguous to underground oil pipeline surface in the Khanty- Mansiysk autonomous region territory (Ugra). Soil samples for microbiological analysis were taken in an amount of 25±5 g and converted into suspension. Sulfate-reducing and thionic bacteria quantity was determined by serial tenfold dilutions method. For sulfate-reducing bacteria cultivation a sterile Postgate's substratum was used. A test-tubes with a sterile substratum were used as a control samples to standardize an examinations. An amounts of microbial cells were determined in 1ml of suspension and in 1g of soil sample. For authotrophic thionic bacteria cultivation a seeding was produced in a test- tubes with Beyerinck's substratum. Bacteria quantity is calculated in colony forming unit (CFU) per 1g of soil. Biometric analysis was carried out by toolkits STATISTICA-6 and BIOSTATISTICS using, and by dint of Microsoft Excel responsibilities. In all statistic analysis procedures values critical level p was assumed to be 0.05, herewith a “p” indexes were ranked in 3 levels of statistically significant differences: $p<0.05$; $p<0.01$; $p<0.001$. Allocation normality check was conducted by Shapiro- Wilk's test using. Fischer's F-criterion was used for general variances equality hypotheses testing. Quantitative attributes average sample values are present in the text as M±SE (M- an average sample, SE- standard average error).

4. Results and discussion

Corrosive destructions in microscopic level may be formed in zones of microorganisms accumulation. Microorganisms presented in soil stimulates a pipeline steel corrosion. To study the nature and composition of