Equipment for paraffin removal from oil pipelines in order to ensure energy saving in Arctic conditions

K F Gabdrakhmanova¹, N N Soloviev², G R Izmaylova¹, L S Kuleshova¹ and S R Marupov¹

¹Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54a, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russia
²LLC Gazprom VNIIGAZ
Staraya Basmannaya str., 20, b. 8, Moscow, Russia

E-mail: klara47@mail.ru

Abstract. The paper describes a new method for solving one of the global problems – paraffin removal from pipelines. The problem is relevant for all oil producing and transporting companies of the Russian Federation and other countries. The method for solving these problems has several advantages, including duration of the overhaul period, high removal efficiency and profitability due to the use of fuel cells. The method allows for maintaining a constant temperature equal to the melting point of paraffin.

1. Introduction

Today, a decrease in operating costs of paraffin deposit removal and prevention which are seasonal in nature and reach 60 % or more in the autumn-winter period is a crucial task of the oil industry in arctic conditions [1, 2]. With these high costs, the performance of the paraffin cleaning devices in arctic conditions is no more than 10 km per day. In this regard, new methods which are cheaper and more technologically efficient are being studied [3].

Since the oil pipelines are mounted above the ground on concrete pylons, they are highly susceptible to seasonal fluctuations at temperatures varying from –50 to 50 °C. The lack of effective heat insulating coatings on the outer surface of oil pipelines leads to an abnormal increase in the rate of paraffin deposit formation on their inner surface which makes the cleaning process much harder and reduces the performance of cleaning devices, especially in autumn and winter [4, 5].

Analysis of the efficiency of devices used for cleaning the internal surface of oil pipelines is presented in figure 1. It shows that there is no alternative to thermal and scraper-type devices provided that the source of thermal energy is autonomous and has a large working life which is sufficient to service large spans between pumping stations up to 100 km. A fuel cell can be used as a source of thermal energy with a large working life. A fuel cell is a chemical current source or an electrochemical generator for converting chemical energy into electrical one.
2. Materials and methods
Sulfuric acid is used as an electrolyte in the fuel cell, and hydrogen is used as a fuel which is combined with oxygen in the oxidizer. As a result of the chemical reaction, hydrogen and oxygen are converted into electricity [6, 7]. As a result of this process, water is formed and a large amount of heat is released.

3. Method of application
Under pressure developed by products 2, the technological projectile consisting of two containers (heat-generating container 3 and scraper-mechanical container 4 connected with cardan hitch 5) moves inside main pipeline 1 (Figure 2). Both containers are held on the axis of the main pipeline by wheel centralizers 6 and are driven by the hydraulic resistance of the transported product using elastic cuffs 7 which cover the gap between containers 3,4 and the inner wall of pipeline 1. During the axial movement of technological containers 3 and 4, the inner wall of main pipeline 1 is cleaned from paraffin softened by heat generating container 3 [8, 9].

Figure 1. Modern equipment for cleaning oil pipelines from paraffin.
When moving along the axis of main pipeline 1 of the technological system consisting of heat generating container 3 and scraper-mechanical container 4, counter-flow 12 of transported product 2 flows into container 3 through holes 10 on its front surface, washes the walls of fuel cell battery 9 through which hydrogen contained in the transported product enters the fuel cells and heats them due to the decomposition into protons and electrons. Then, the product heated to a certain temperature which is higher than the paraffin crystallization temperature (≥25-30 °C) and transported through holes 11 on its rear surface 13 washes the inner wall of main pipeline 1 and softens paraffin [10, 11].

4. Conclusion
The equipment described in this article reduces labor intensity of maintenance per 1 km of the main pipeline, eliminates the need for supplying power lines, reduces consumed electrical power by using fuel cells as power sources using atomic hydrogen as a fuel contained in the transported products, and contributes to high performance with a long-range of up to 100 km or more, a high failure interval of up to 50 hours and a small payback period of up to 1.5-2 years or less.

References
[1] Bose S, Kuila T, Nguyen TXI, Kim NH and Lau K 2011 Polymer membranes for high temperature proton exchange membrane fuel cell: Recent advances and challenges Prog. Polym. Sci. 36(6) 813–43
[2] Okada O and Yokoyama K 2001 Development of polymer electrolyte fuel cell cogeneration systems for residential applications Fuel Cells 1(1) 72–7
[3] Bakhtizin R N, Fattakhov I G, Kadyrov R R, Akhmetshina D I and Safiullina A R 2015 Destruction of the resins structure due to heating Oriental J. of Chemistry 31(2) 795–803
[4] Fermeglia M, Cudicio A, DeSimon G and Longo G 2004 Process simulation for molten carbonate fuel cells Fuel Cells 5(1) 66–79
[5] Alhassan M and Umar Garba M 2006 Design of an Alkaline Fuel Cell. Leonardo Electron J. Pract. Technol. (9) 99–106
[6] Grezina O A 2018 Assessment of the results of acid implosion stimulation of the near-wellbore area based on statistical data IOP Conf. ser. Earth Env. 194(8) 082016
[7] Goryunova M V, Kuleshova L S and Khakimova A I 2017 Application of signal analysis for
diagnostics, *IEEE (Int. Conf. on Industrial Engineering, Applications and Manufacturing (ICIEAM))*

[8] Gabdrakhmanova K F, Izmailova G R, Larin P A, Vasilyeva E R, Madjidov M A and Marupov S R 2018 Nomogram method as means for resource potential efficiency predicative aid of petrothermal energy *J. Phys. Conf. ser.* **1015**(3) 032036

[9] Gabdrakhmanova K F, Izmaylova G R and Larin P A 2018 The way of using geothermal resources for generating electric energy in wells at a late stage of operation *IOP Conf. ser. Earth Env.* **194**(8) 082012

[10] Mukhametshin V V 2018 Rationale for trends in increasing oil reserves depletion in Western Siberia cretaceous deposits based on targets identification *Bull. of the Tomsk Polytechnic Univer. Geo Assets Engineering* **329**(5) 117–24