ЕКОЛОГІЯ І ВИРОБНИЦТВО

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INTEGRATED RESEARCH CLEANING METHODS TUBING POLLUTED TECHNOGENICALLY ENHANCED NATURAL SOURCES ORIGIN

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The aspects of handling materials contaminated with radionclides of natural origin, in particular producing strings (strings) of the oil and gas industry, are analyzed. The results of the analysis of existing methods for cleaning strings are presented. The prospects of using the complex method of cleaning the strings from salt deposits, which is in simultaneous application of hydrodynamic, cavitation and mechanical action, are considered. *Keywords:* ecological safety, strings, natural radionuclides, hydrodynamic method of cleaning, oilfield equipment, cleaning unit for strings.

Дослідження комплексного методу очищення насосно-компресорних труб, забруднених радіонуклідми природного походження. Бондар О.І., Денисенко І.Ю. Проаналізовано аспекти поводження з матеріалами, забрудненими радіонуклідами природного походження зокрема насосно-компресорні труби (НКТ) нафтогазовидобувної промисловості. Викладено результати аналізу існуючих методів очищення НКТ. Розглянуто перспективи застосування комплексного методу очищення НКТ від сольових відкладень, який полягає в одночасному застосуванні гідродинамічної, кавітаційної та механічної дії. *Ключові слова:* радіаційна безпека, екологічна безпека, насосно-компресорні труби, природні радіонукліди, гідродинамічний спосіб очищення, нафтопромислове обладнання, установка для очищення НКТ.

Исследование комплексного метода очистки насосно-компрессорных труб, загрязненных радионуклидами природного происхождения. Бондарь А.И., Денисенко И.Ю. Проанализированы аспекты обращения с материалами, загрязненными техногенно усиленными источниками природного происхождения в частности насосно-компрессорные трубы (НКТ) нефтегазовой промышленности. Изложены результаты анализа существующих методов очистки НКТ. Рассмотрено перспективы использования комплексного метода очистки НКТ от солевых отложений, который заключается в одновременном применении гидродинамического, кавитационного и механического действия. *Ключевые слова:* экологическая безопасность, насосно-компрессорные трубы, природные радионуклиды, гидродинамический способ очистки, нефтепромысловое оборудование.

Problem definition and its relationship with important scientific and practical tasks

Background research caused aggravation question environmentally sound treatment of accumulated on specially equipped sites (ten thousand tonnes) of waste processing equipment (strings contaminated with salt deposits containing natural radionuclides (^{232}Th, ^{226}Ra

and ^{40}K), which was formed in enterprise performance oil and gas industry.

The exposure dose of salt deposits is up to 500 mR / h, which is more than 40-50 times higher than the natural background radiation [1]. It is dangerous in terms of radiation and environmental safety. Temporary storage of strings does not solve one of the main isue – to minimize negative impacts on the environment and human.

Based on the above idea it was implemented reduction of environmental load of contaminated equipment by applying environmentally and economically acceptable way of cleaning the strings from salt deposits containing natural radionuclides by manufacturing and testing units for cleaning strings.

Study of cleaning of waste processing equipment involved in the oil industry, scientists such as V. Shumlyansky, A. Subbotin, M. Zyravel and others were engaged. Significant contribution to the study on environmental and radiation safety were done A. Serdyuk, A. Matoshko, I. Los, A. Mnuhin and many other scientists [2-3].

But despite the significant achievements of this issue, handling of materials contaminated with technologically enhanced naturally occurring sources, including oil and gas strings remains relevant today because the technology is not proven to implementation. Research of cleaning strings from salt deposits containing natural radionuclides associated with previous publications [4-6] on this topic.

Experimental study on the technology of decontamination strings comprehensive way held at the head office of the State Corporation "Ukrainian State Association" Radon "(hereinafter – SC" UkrDO "Radon") of the State Specialized Enterprise "Central Enterprise for Radioactive Waste Management" (hereinafter – TSPPRV DSP), located in the exclusion zone and zone of unconditional (obligatory) resettlement (the pollutants and BZ (o) B).

Installation for cleaning strings housed in a special room in conditions as close to natural. During the execution of experimental work carried out constant dose control using certified dosimetrists dosimeter-radiometer MKS-01R, zav. №859 859 and SCS – 96-01, block 96 BDZA T №281. Work performed under the terms of measures of safety and radiation safety stipulated rules and regulations.

Before purification measuring the exposure dose of γ-radiation (the ER) and flux density of α- and β-particles on the inner and outer surfaces were performed. Also, repeated measurements were performed after decontamination tubes and obtained after decontamination of radioactive materials in the form of sludge.

Strings were different sizes – from 6 to 10.5 m. A pipe strings supplied strings length 9,5-10,5 m. Geometric pipe size strings complied GOST 633-80. The weight strings pipes GOST 33-80. Tolerances strings pipe sizes are small, making them practical.

Test samples had different strings sizes:

- the length – 6 m to 11.5 m;
- pipe diameter – from 30 mm to 160 mm.

The thickness of the pipe wall was 5-10% of the outer diameter of the pipe. Strings had an anti-corrosion coating, but due to constant mechanical stress and interaction with aggressive media greatly subjected to corrosion and accumulation of salt deposits (Fig. 1a, b).

а

б

Fig. 1 (a, b) strings, exposed to corrosion and accumulation of salt deposits on their inner walls

The technology of cleaning the surface of the strings is as follows. Special traffic strings delivered to the place of decontamination. Before deactivating all strings and weighted measurements conducted α β γ – radiation exposure dose. Each strings purified complex method (Fig. 2).

The installation consists of a high pressure system that delivers the working fluid (water) into the contaminated pipes; specially developed and patented nozzle which achieves a complex hydrodynamic cavitation performance and frame, which is fixed strings. Nozzle inserted into the inner cavity of the pipe under the influence of fluid supply pump high pressure comes into rotary motion, acting on a layer of sediment jets of high-pressure jets of high-energy (cavitation) effects on surface and mechanical destruction (cutting) layer of sediment.

Using of a specially designed nozzle allows reaching purification strings. The resulting sludge gathered in the receiving chamber and then determined the level of radioactive contamination transferred to long-term storage.

In the world use various methods of cleaning the strings of salt deposits containing natural radionuclides.

Through analysis of existing technologies and their description in the literature [1-7], has been allocated the following methods of cleaning oil and gas processing equipment, chemical, mechanical, hydrodynamic, cavitation. General characteristics, advantages and disadvantages of these methods shown in Table 1.

Comparative characteristics of these methods makes it possible to conclude that they all have advantages and disadvantages. Chemical and mechanical compared to the other is quite accessible for use. Thus, there is a wide practice of using mechanical means both abroad and in Ukraine.

Some attempts decontamination strings mechanically made experts of the State Specialized Enterprise "Kharkov State Interregional Specialized Factory" DC UkrDO "Radon" (DSP "HDMSK"), which took on a contractual basis for temporary storage of strings.

Characterization strings oil and gas industry, contaminated natural origin was to:

- measuring the dose rate exposure dose of 0.1 m and at a distance of 1 m from the surface of the strings for the definition of radioactive material

Table 1

Analytical study of the advantages and disadvantages of existing methods of cleaning oil equipment

Method name	Cleanser	Advantages	Disadvantages
Chemical	Different kinds of reagents	A wide range of reagents for various compositions pollution	Do not ensure complete removal of salts, aggressive reagents can damage the walls of process equipment required special conditions for use of the method, financially costly
Mechanical	Various mechanical tools	Available structurally simple	Damage to the walls of the process equipment
Hydrodynamic	Water jet installation of various designs, which are equipped with a nozzle for supplying a jet of water under high pressure	Versatile, walls are damaged equipment	In terms of wells using is limited
Cavitational	Water jet installation using special cavitation nozzle	High performance equipment are damaged wall	Energy-consuming
The method of acoustic impact	Involves the use of ultrasound generated emitters of different configurations	Environmentally friendly, the walls are damaged equipment	Inefficient for cleaning pipes of considerable length, damaged walls of the process equipment, uneven cleaning

and, consequently, the level of physical protection;

- exposure dose measurement flux density and α-, β-particle radiation safety for personnel during works on-site storage of strings;

- measuring the specific activity of naturally occurring radionuclides analysis safekeeping strings and determine the possibility of removal from regulatory control after decontamination.

Results of decontamination strings mechanically are shown in Table 2 [8].

A total for deactivation mechanically was transferred 35,436 kg strings, of them are not subjected to decontamination 3372 kg, which is 9.5% of the total.

All strings that were sent for decontamination at SSE was found TSPPRV radiative waste [9].

Indicators secondary activity radioactive waste (hereinafter – RW) are formed by mechanically decontamination strings below the strings to decontamination activity [8].

As a result of this work flaws complex pipe cleaning method, namely the observed cases of incomplete cleaning some sample strings was found. However, mechanical fragmentation method requires strings. In addition, dust and aerosols formed. Checked in cases of dam-

Table 2

The results of experimental studies on decontamination strings mechanically

Characteristics of strings samples	Lot number strings			
	1	2	3	4
Weight strings party, held deactivation kg	720	10 972	10 124	13 620
The initial activity of the party strings, Bq	1,2x105	1,8x106	1,7x106	2,3x106
Weight deactivated strings, kg	226	10 394	8 832	12 240
The percentage of strings that passed deactivation, %	31,39	95,12	87,24	89,87
Number deactivated fragments strings, units	23	1 156	864	1 226
The mass of fragments not undergone decontamination, kg	492	490	1 196	1 192
Mass of secondary radioactive waste, kg	2	88	96	92
Key secondary radioactive waste, Bq	3,8x104	9,7x105	1,2x106	1,0x106

age to the internal walls of the strings, not allowing re-use in oil and gas industry.

On the ground of handling strings SSE "TSPPRV" strings diameter of 76 mm and a length of 10 m, wall thickness of 8 mm are hosted.

The main radionuclides in technologically contaminated strings is ^{226}Ra and ^{232}Th.

The maximum specific activity is: for ^{226}Ra – 570 kBq / kg, ^{232}Th – 340 kBq / kg, minimum – 0.03 kBq / kg and 0.01 kBq / kg, respectively. ^{226}Ra and ^{232}Th characterized gamma, beta and alpha radiation.

The specific activity of both radionuclides – ^{226}Ra and ^{232}Th concentrated in the first 1 mm layer on the outside as well inside of the pipes. In the second 1-mm layer of both radionuclides specific activity decreases on average 75 times. The most polluted is the inside of the pipes. For the most contaminated strings surface contamination levels exceed release after removing the second layer of the inner surface of the pipes.

The level of exemption from regulatory control of natural radionuclides is 1 kBq / kg.

EDR from the strings range from background values up to 40 mSv/h, the density of beta particles is from 2,000 units β-particles/(cm 2 × min), density of alpha particles ranges from zero to 160 α- particle/(cm^2 × min).

The principle of operation units for cleaning strings based on a combination of hydrodynamic simultaneously, cavitation and mechanical stress.

Experimental setup has the following main features:

- production capacity – 3-4 tubes/ hour;
- electricity consumption – 20-70 kW/h;
- flow of water through the cleaning head – 30-50 liters / min. The system allows cleaning of high water in the recirculation mode. The minimum amount of water – up to 300l 100-150 tons of pipes.

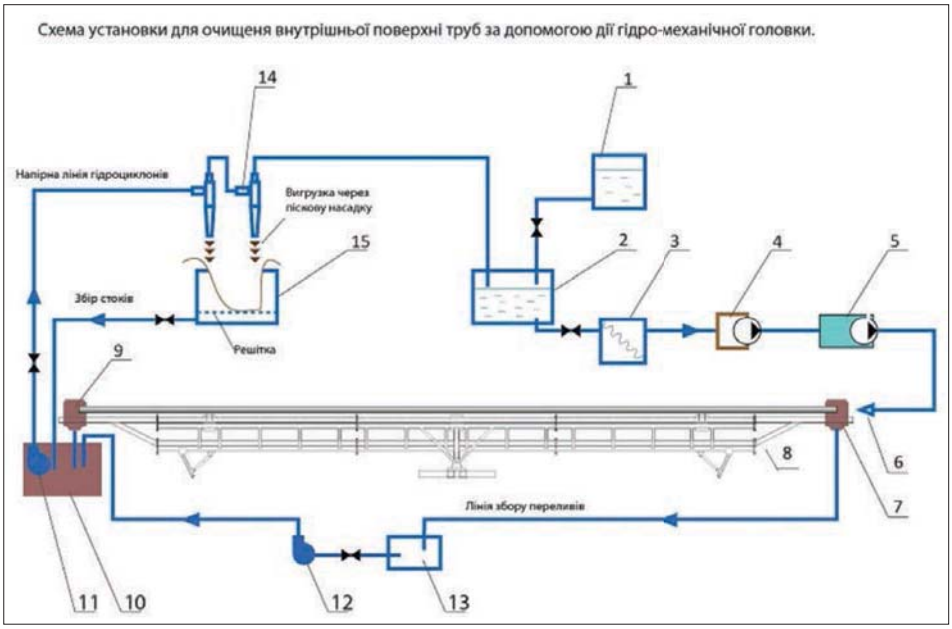

Fig. 2. Apparatus for cleaning the internal surface of pipes from salt deposits

Tests were conducted in compliance with radiation safety in accordance with the prepared temporary technological requirements. For research strings were taken in an amount of 5 pieces. Each pipe was marked with input and dose control.

Incoming inspection results are shown in Table 3.

Table 3

The results of radiation monitoring input strings

Number of sample tubes		Radiation indicators			The thickness of the salt deposits, mm	Protocol № ___ of ___
		Power exposure dose, mSv/h	β-flux density particles B-particles/ min* cm^2	Fluence α-particles, α-particles/ min* cm^2		
B3	tube	28	930	4		№2 25.04.2015.
	sludge	142	22800	47	4	
B7	tube	26	1117	3		№5 23.05.2015.
	sludge	980	38000	27	5	
A4	tube	0,7	31	1,5		№6 24.05.2015.
	sludge	170	630	3	4	
A6	tube	31	1090	3		№7 24.05.2015.
	sludge	186	36000	70	6	
A5	tube	42	1175	3		№9 27.05.2015.
	sludge	220	29500	63	4	

It was found that the thickness of salt deposits on the inner surface of the strings was 4.6 mm. The average exposure dose tubes – 25.54 mSv/h, with a density of β-particles averaged 868,6 β particles/min. * Cm^2, and α-2,9 α-particles particles/min. * Cm^2. Indicators flux density α and β-particles in the slurry is ten times higher than those of the tube.

Also, a study of the chemical composition of sediments captured first layer strings is reflected in Table 4.

Table 4

The composition of sediment removed first layer strings

№	Chemical element	Indexes, %
1	Pb	**97.69**±0.06%
2	Sb	**1.82**±0.06%
3	Sn	**0.26**±0.01%
4	Zn	**0.19**±0.00%
5	Cu	**0.04**±0.00%

The main chemical elements in the salt deposits are Pb, whose contribution is 97.69%. The lowest content of Cu – 0,04%.

Thus, the radioactive material in the form of strings and other equipment are dangerous due to high levels of surface contamination α, γ emitting radionuclides. Handling strings contaminated by salt deposits from the content of natural radionuclides is in accordance with the requirements NRBU- 97, under health and safety regulations fourth group aimed at reducing the dose chronic human exposure to man-caused reinforced springs naturally occurring in the home and at work.

Conclusions

Given the results of existing research and experience on issues related to improving the environmental safety of oil and gas industry enterprises and adjacent areas by reducing the amount of radioactive strings and according to their storage occupied territories, we believe that further research is necessary to continue to search for the most an acceptable method of cleaning the strings and its environmental and economic evaluation and justification of the usefulness of this technique.

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