SOLID RADIOACTIVE WASTE CEMENTING BY IMPREGNATION WITH HIGHLY PENETRATING GROUT

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ABSTRACT

Moscow SIA «Radon» has created a method of solid radioactive waste (SRW) impregnation with highly penetrating cement grout and experimental-industrial installation of cementation by impregnation in containers fine-grained and mixed SRW is introduced [1]. For impregnation cement grout is used on the basis of the multi-component binding material "Bison" developed at The Institute of Ecotechnologies [2]. The new method and new binding material does not increase the volume of a final product in comparison with initial poured volume of waste products, simplifies the process of cementation, increases its radiation safety, to and reduces expenses for erection and service of near-surface repositories of radioactive waste. In the report results of trial tests are submitted.

INTRODUCTION

Low and intermediate level solid radioactive waste (SRW) cementation is a prevalent process in the world. However, existing cementation methods cause an increase of the final product volume when compared with the initial poured volume of waste. SRW are as a rule friable, small-grained or lump fragmented materials, which have voids in poured volume. Volume of voids in friable SRW makes up to 40-45% of poured volume. Filling the voids between SRW particles with cement grout can be sufficient for formation of a cement matrix and will result in a final product volume being equal to the initial poured volume of waste. This decreases the requirement of repository space for cemented SRW from 1,5 to 2 times, reducing expenditures for erection and service of new repositories.

Main Results

The utility of hydrodynamics dependencies (hydraulic resistance of granular layer on liquid properties, geometric characteristics of layer and rate of liquid movement through tracts) and mass transfer (quantity of component of heterogeneous liquid transferred during a unit time through a unit free volume of granular layer) for estimation of SRW impregnation parameters was experimentally proved.

Parameters of impregnation process and criteria of impregnation quality were determined: pressure of grout feeding P=0,02-0,1 MPa, linear rate of impregnation 4-8 cm/min, decrease of grout density during impregnation – not more than 6% of the initial value, which guarantees reliability of the process and formation of compounds with required properties both at the bottom and top of layer. Properties of high penetrating cement grouts and results of experimental definition of optimum pressure of grout feeding are submitted in Table I.

Table I. Experimental Values of Pressure of Grout Feeding and Properties High Penetrating Cement Grout.

Water/Cement Ratio	Properties of Grout				Pressure of Grout Feeding, MPa
	Grout Density, g/cm^3	Floatability, mm	Settling, %	The Beginning Setting, Hour-min	
0.4	1.859	<100	0	1-35	0.15[a]
0.5	1.743	160	0.7	3-10	0.12
0.6	1.670	200	1.5	>3	0.10
0.7	1.598	216	2.7		0.09
0.8	1.582	220	3.4		0.08
0.9	1.534	240	5.3		0.05
1.0	1.482	>240	>6	>3	0.04
1.2	1.416				0.04
1.4	1.370				0.03
1.6	1.335				0.02
2.0	1.260				0.02

[a] At pressure from above 0,15 MPa impregnation occurs non-uniformly.

Compositions of high penetrating cement grouts were defined on the basis of binding material "Bison" containing as the main components: cement with specific surface more than 10000 cm^2/g and polymer of polyhexametylenguanidine class (PHMG) 1-2 wt.% of cement mass [3].

It was shown that polymer PHMG improves parameters of impregnation – increases flowability of cement grout in 1,2-1,5 times, reduces its demixing in 1,3-2 times, allows without lose of grout quality impregnating more in 1,5-2 times volume of SRW, increases durability and frost-resistance in 1,8-2,7 times, reduces leaching rate of Cs-137 in 1,5-2 times, promotes the fastest growth of durability on early terms of hardening (Figure 1). Results of investigation of final product of ash residue impregnation are submitted in Table II.

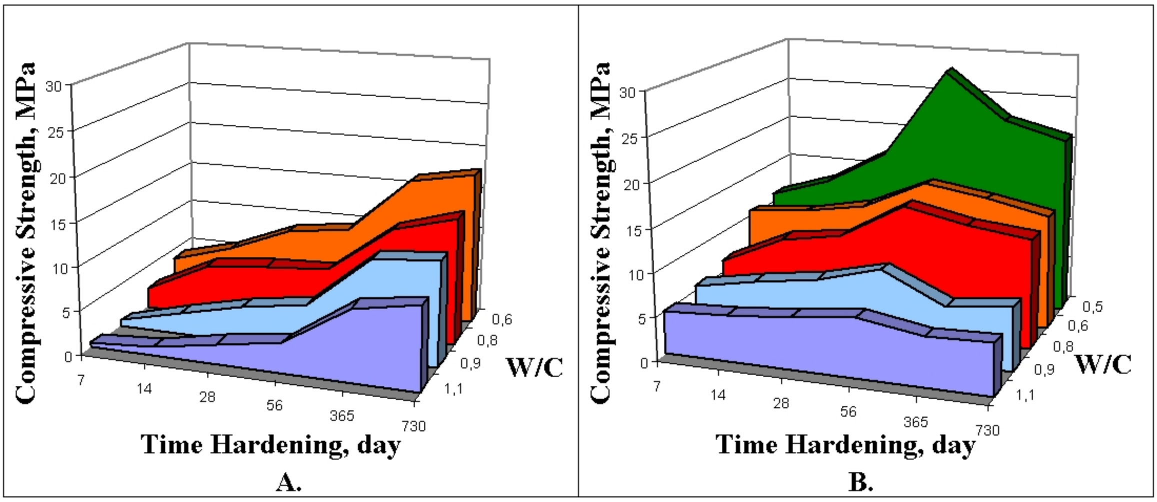

Fig. 1. Dynamics of hardening cement compounds containing of ash residue 65-70 wt.%:

A - without the additive; B - with additive PHMG; W/C (Water/Cement Ratio)

Table II. Properties of Cement Grout (Content of Ash Residue in Cement Compound 60-70wt.%).

Water/ Cement Ratio	PGMG	Compressive Strength, MPa			Leaching Rate Cs-137, $g/cm^2 \cdot day$
		28 days	after 30 cycles of freezing - thawing	after immersed in water for 90 days	
0,5	-	UP[a]			
	+	17.5	17.6	30.2	$1.3 – 2.1 \cdot 10^{-4}$
0,6	-	7.2	6.3	6.3	$6.8 – 9.0 \cdot 10^{-4}$
	+	12.7	11.7	16.6	$3.9 – 7.3 \cdot 10^{-4}$
0,8	-	6.6	6.0	5.8	$7.2 – 9.8 \cdot 10^{-4}$
	+	11.0	10.5	14.8	$5.1 – 8.6 \cdot 10^{-4}$
0,9	-	UP			
	+	8.1	7.2	9.9	$6.3 \cdot 10^{-4} – 1.0 \cdot 10^{-3}$
1,1	-	UP			
	+	6.1	5.5	6.5	$8.8 \cdot 10^{-4} – 1.0 \cdot 10^{-3}$

[a] Cement samples had unsatisfactory properties.

Experimental-industrial tests of impregnation cementing have been carried out in the determined range of parameters and compositions of various types of SRW dislocated in containers of different sizes and configuration:

1. impregnation of ash residue from RW incineration placed into a 200-liters drum (Figure 2);
2. impregnation of mixed SRW (90 vol.% – metal scrap, 10 vol.% - ground), located into a 4 m^3 container (Figure 3);
3. impregnation of coarse-grained SRW layer (fragments of construction materials) in a near-surface repository 8800×4200×4400mm (Figure 4).

A. B.

Fig. 2. Cementation by a impregnation method of ash residue in 200 l a barrel:
A - trial installation; B – final product.

A. B.

Fig. 3. Cementation by a impregnation method of mixing SRW in 4 м^3 container:
A - SRW in 4 м^3 container; B - final product.

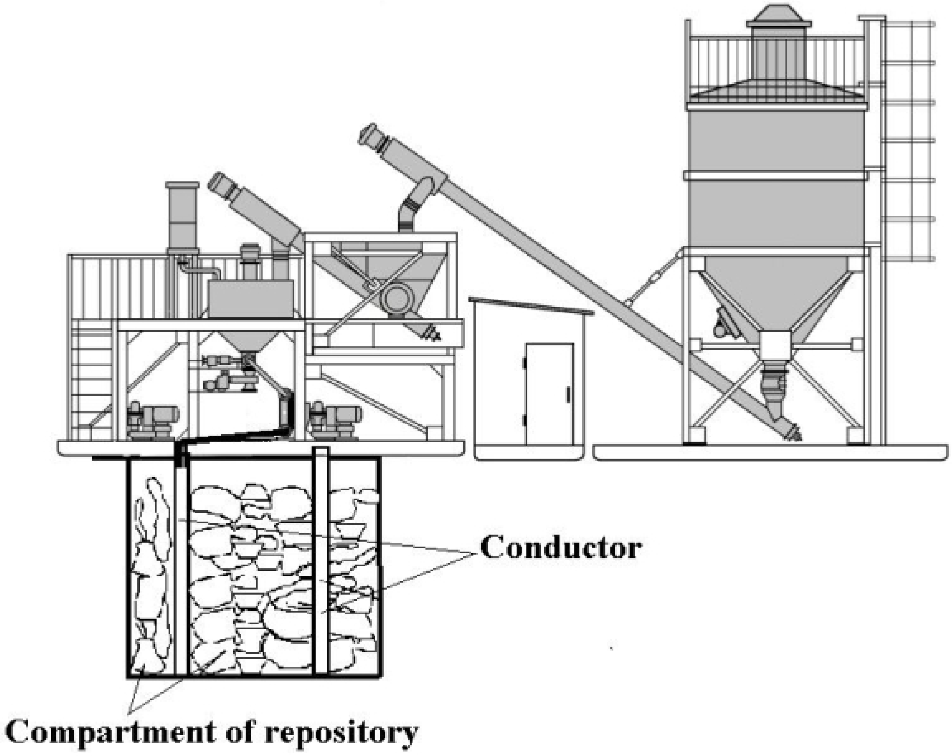

Fig. 4. Cementation by a impregnation method of coarse-grained SRW layer (fragments of construction materials) in a near-surface repository 8800×4200×4400mm.

It was found out that properties of cement compounds obtained by means of impregnation in experimental-industrial scale satisfied the requirements of GOST R 51883-2002 [4].

CONCLUSION

Research has confirmed the potential for an SRW cementation method with a highly penetrating grout. A range of parameters and compositions of various types of SRW were determined for containers of different sizes and configurations. The method can be recommended for application.

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