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New Technology of Destruction of Waste of the 1st and 2nd Class of Danger

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***Abstract*— The author has developed and patented a high temperature smelting unit with sodium coolant for thermal treatment of hazardous waste. In the article, the unit's test results have been given with respect to different waste types, including radioactive and municipal solid wastes. The authors have established that all types of waste can be treated in the developed unit, being converted into electricity and gas (can be emitted into atmosphere after appropriate treatment), or into slag that fixes heavy metals in the crystal lattice of oxides and makes them insoluble.**

***Index Terms*—sodium cooling, thermal treatment of hazardous waste, municipal solid waste, radioactive waste.**

I. INTRODUCTION

Wastes and associated pollution of our planet have become an urgent and global environmental problem which is dangerous for human health and natural environment. The severity of the waste problem was not so noticeable before. Until a certain time, nature coped with waste recycling itself, but the technical progress of mankind played an important role at this moment: new materials appeared, the decomposition or processing of which by natural means can last more than one hundred years, and such anthropogenic pressure on nature is no longer possible; modern volume of waste produced is huge. Approximately 500 to 800 kg of waste per year is accounted for each urban resident. In some countries it is up to 1000 kg. And their number is growing all the time.

The organization of the orderly treatment of waste production and consumption - that is, their collection, disposal, neutralization, processing, use, destruction, etc. - In recent years it has become one of the most acute environmental problems of the whole world.

If all accumulated wastes were untreated and disposed into one pile, a mountain as high as Elbrus, the highest point of Europe, would appear. At present, 44 billion tons of mineral resources are extracted from the Earth's interior in the entire civilized world, excluding the rock mass transported during the preparatory work in the mines, the construction of roads, housing. In North America, 1.6 kilograms of garbage per day per resident; in Europe - 1.5; in the CIS - 1.2; in Asia - 0.4; in Oceania, 0.8; in Latin America - 0.6; in Africa - 0.5.

II. GENERAL BACKGROUND

State of the art

In recent years, the problem of waste has become global.

Today there are several technologies of waste treatment. For example, metals are processed into parts, and aluminum is used for the manufacture of various materials, and energy is saved (80–90% lower) than if aluminum is obtained from ore. Textile waste is crushed and used to give strength to paper products, and old tires are used to produce rubber products; plastic is "converted" into synthetic wood, glass is crushed and new products are prepared, garbage and food waste are used to prepare composts.

MSW combustion at high temperatures in experimental industrial scales in this work was carried out:

- in the Vanyukov furnace at a temperature of about 14,000 ° C on the surface and in the layer of bubbling slag;
- in the Romelt aggregate on the surface and in the layer of molten slag at a temperature of 16000 ° C;
- in plasma furnaces of small productivity with maximum temperatures of the working space up to 25000C.

Thermal treatment of regular MSW in experimental units demonstrated that the products of MSW incomplete combustion, including dioxins and furans, were absent in the effluent gases. This can be attributed to sharp increase in the rate of chemical reactions upon temperature increase. According to [25], the time of dioxins' complete destruction at 1,000 °C is 2 seconds, at 1,700 °C – 5•10-4 s.

III. RESULTS

In order to determine possibility of safe use of slags generated upon MSW treatment according to the proposed technology, we analyzed heavy metals composition, properties and washout rate from such slags.

Typical MSW, collected from garbage containers in Chelyabinsk, were combusted on the layer of preliminary molten acid slag under laboratory and pilot conditions. The obtained slag samples were crushed, mixed and analyzed (wet method) (Table 1).

Table 1. Average oxide content in slag, wt %

SiO_2	CaO	Al_2O_3	MgO	ΣFeO	NiO	K_2O+Na_2O
60.3	12.3	14.3	0.85	8.87	0.04	2.72

Content of heavy metals in terms of their oxides was determined in slag samples averaged by atomic absorption. It varied in the following ranges, wt % (Table 2):

Table 2. Heavy metals content in slag, wt %

Cr_2O_3	MnO	ZnO	PbO	TiO_2	CuO	V_2O_5
0.018	0.101	0.026	0.016	0.087	0.010	0.009
0.020	0.105	0.028	0.017	0.090	0.012	0.012

It can be seen that content of heavy metals in the slag samples under investigation is moderate and does not

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exceed their content in ash and slag wastes of waste incineration plants [26].

It is known that acid slags are characterized by high strength and hardness, they are practically not destroyed under the impact of atmospheric moisture. This is confirmed by our experiments with slags generated upon MSW combustion.

Slag samples were milled to particle size of up to 0.5 mm and 0.5-3.0 mm. The obtained powders were poured with distilled water and hold for 7 days. After that, the content of heavy elements in water was determined by atomic emission analysis in the laboratory of the South Ural State University. The following average contents of heavy elements were obtained, mg/l (Table 3):

Table 3. The average contents of heavy elements in slag, mg/l

Particle size	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
0.5-3.0 mm	$8 \cdot 10^{-4}$	$2.4 \cdot 10^{-3}$	0	0	$4.8 \cdot 10^{-3}$	$5.6 \cdot 10^{-3}$	0	0	$5.3 \cdot 10^{-3}$
< 5 mm	$8 \cdot 10^{-4}$	$2.4 \cdot 10^{-3}$	$1.0 \cdot 10^{-3}$	0	$8.8 \cdot 10^{-3}$	$4.3 \cdot 10^{-3}$	0	$1.6 \cdot 10^{-3}$	$3 \cdot 10^{-3}$

From the given data it follows that heavy metals are in fact not washed from slag. Therefore, the crushed acid slag generated upon MSW high temperature utilization according to the proposed procedure is suitable for use in construction without any restrictions.

Tests performed in R&D Institute of construction materials (NIISTROM, Chelyabinsk) demonstrate that when it comes to operating characteristics, the crushed slag generated upon MSW utilization is on a par with the crushed granite.

Summary input/output balance of hazardous waste treatment is shown in Table 4.

Table 4. Summary input/output balance of waste treatment

			kg/t	%	nm^3/t
Input	Wastes		1,000	13.0	
	Oxygen		552	7.2	389
	Nitrogen		1,756	22.8	1,406
	Air		4,400	57.1	3,439
	Adsorbent		1	0.01	
		Total	7,709	100	
Output	Metal		22.0	0.3	
	Slag		172.3	2.2	
	Effluent gas		7,506	97.4	5,917
	Dust		8.8	0.1	
		Total	7,709	100	

Table 5. Summary input/output balance of waste treatment

			kg/t	%	nm^3/t
Input	Wastes		1,000	13.0	
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	Dust		8.8	0.1	
		Total	7,709	100	

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The consolidated material balance of MSW recycling in the unit is given in table 4, the consolidated heat balance of this process in table 5, the composition of the waste gas from the pipe sewage treatment plants in table 6.

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Table 6.The chemical composition of the exhaust gas (at 70°C)

	Component content										
	In gas		In air		Total						
	kg/t	nm^3/t	kg/t	nm^3/t	kg/t	nm^3/t	% weight	% volume	mg/nm^3		dew t, °C
									actually	norm	
N_2	3147	2518	2000	1600,26	5148	4118	68,6	69,6			
CO_2	1102	561		32,7	1102	561	14,7	9,5			
H_2O	632	786	26	419,0	658	819	8,8	13,8			**52**
O_2			599		599	419		7,1			
HF	$2\cdot10^{-6}$				$2\cdot10^{-6}$				$3\cdot10^{-4}$	1	
HCl	$1\cdot10^{-8}$				$1\cdot10^{-8}$				$2\cdot10^{-6}$	10	
SO_2	0				0				0	50	
Cd	0				0				0	0,05	
Dust incl. CdS	0,0222 0,00001				0,0222 0,00001				3,7 0,002	30 0,05	
Total	4880	3865	2625	2052	**7506**	**5917**	100	100			

The collected dust compositions are given in tables 7 and 8.

Table 7. The composition of the collected dust.

		M	Component content	
			kg/t	%
Chloride	NaCl	58,5	3,6188	40,93
Sulfate	Na_2SO_4	142	3,4286	38,78
Oxides	Fe_2O_3	160	0,8437	9,54
	ZnO	81,4	0,6194	7,01
	SiO_2	60	0,1658	1,88
	∑		1,6289	18,42
Sulfide	CdS	144,4	0,0044	0,05
Fluorides	NaF	42	0,1219	1,38
	CaF_2	78	0,0098	0,11
	∑		0,1317	1,49
Carbonate	Na_2CO_3	106	0,0293	0,33
Total			8,842	100

– melting of MSW mineral constituent, obtaining of liquid overheated slag and, if necessary, slag composition adjustment by flux addition, and providing safe and efficient use of such slag for construction;

– minor amount of dust which probably should be buried;

– possibility to obtain charge ingots of ferrous metal from MSW scrap metal;

– fixation of substantial amount of heavy metals in the resulted slag and charge ingots;

– production of numerous marketable products during MSW treatment (metal, slag, electricity, thermal energy) for subsequent sale.

The proposed high temperature smelting unit design can be applied for all waste types.

The applied mode of waste combustion with minimum air excess prevents penetration of nitrogen oxides into effluent gas and eliminates generation of free chlorine in gas. Early high temperature neutralization of effluent gas completely prevents hazard of secondary dioxin formation; and two-stage low temperature dry gas scrubbing decreases its contamination to the level meeting the requirements of valid regulations.

Table 8. The composition of the collected dust.

	M	Component content	
		kg/t	%
Na	23	2,6129	29,55
Fe	56	0,5906	6,68
Si	28	0,0774	0,88

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Ca	40	0,0050	0,06
Zn	65,4	0,4976	5,63
S	32	0,7736	8,75
Cl	35,5	2,1960	24,84
F	19	0,0599	0,68
Cd	112,4	0,0034	0,04
C	12	0,0033	0,04
O	16	2,0218	22,87
Total		8,842	100

The data given in Tables 4-8 testify to the high technical, economic and ecological efficiency of the proposed technology for the disposal of MSW.

CONCLUSION

The main advantages of the proposed technology are as follows:

– combustion and partial gasification of MSW on surface of abundant molten slag heated to 1,550-1,600 °C, which provides the so-called "thermal shock" – instant heating of loaded MSW to the temperatures above 700 °C that excludes possible generation of dioxins in the most dangerous range of 180-700 °C;

– MSW combustion or gasification in the oxygen atmosphere, providing high temperature (at least 1,700 °C) of free space and, hence, high temperature of gaseous phase, that eliminates generation of MSW incomplete combustion products (including dioxins), or ensures their complete decomposition.

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REFERENCES

1. SA.A. Golubev, Yu.A. Gudim, V.A. Grachev, V.P. Dydychkin, Non-waste thermal processing method of solid public wastes, and unit for its implementation. Russian Patent RU2461776C1, issued September 20, 2012.
2. Yu.A. Gudim, A.A. Golubev, V.A. Grachev, One Stage Pyrometallurgical Recycling of Radioactive Scrap Metal, Pollut. Res. 37 (2) (2018) 549–554.
3. H.K. Jeswani, A. Azapagic, Assessing the environmental sustainability of energy recovery from municipal solid waste in the UK, Waste Manag. 50 (2016) 346–363.
4. R. Bian, D. Xin, X. Chai, A simulation model for methane emissions from landfills with interaction of vegetation and cover soil, Waste Manag. 71 (2018) 267–276.
5. M. Di Gianfilippo, I. Verginelli, G. Costa, R. Spagnuolo, R. Gavasci, F. Lombardi, A risk-based approach for assessing the recycling potential of an alkaline waste material as road sub-base filler material, Waste Manag. 71 (2018) 440–453.
6. P. Gaurh, H. Pramanik, A novel approach of solid waste management via aromatization using multiphase catalytic pyrolysis of waste polyethylene, Waste Manag. 71 (2018) 86–96.
7. L. Wang, Q. Li, Y. Li, X. Sun, J. Li, J. Shen, W. Han, L. Wang, A novel approach for recovery of metals from waste printed circuit boards and simultaneous removal of iron from steel pickling waste liquor by two-step hydrometallurgical method, Waste Manag. 71 (2018) 411– 419.
8. T. Garoma, D. Pappaterra, An investigation of ultrasound effect on digestate solubilization and methane yield, Waste Manag. 71 (2018) 728–733.
9. M. Cuartas, A. López, F. Pérez, A. Lobo, Analysis of landfill design variables based on scientific computing, Waste Manag. 71 (2018) 287–300.
10. C. Dennehy, P.G. Lawlor, M.S. McCabe, P. Cormican, J. Sheahan, Y. Jiang, X. Zhan, G.E. Gardiner, Anaerobic co-digestion of pig manure and food waste; effects on digestate biosafety, dewaterability, and microbial community dynamics, Waste Manag. 71 (2018) 532–541.
11. E.A. Odey, Z. Li, L. Kalakodio, A glance at the world: Composting of organic waste in urban Nigeria, Waste Manag. 71 (2018) I–III.
12. M. Baptista, F. Antunes, M. Souteiro Goncales, B. Morvan, A. Silveira, Composting kinetics in full-scale mechanical-biological treatment plants. Waste Manag. 30 (2010) 1908–1921.
13. A. Zawadzka, L. Krzystek, S. Ledakowicz. Autothermal biodrying of municipal solid waste with high moisture content, Chem. Pap. 64 (2) (2010) 265-268.
14. D. Etengeneng, Municipal Solid Waste Management in Grahamstown, Republic of South Africa, Novia University of Applied Sciences, Raseborg, 2012.
15. C. Wu, T. Shimaoka, T. Komiya, Kinetics of nitrous oxide production by denitrification in municipal solid waste, Chemosphere 125 (2015) 64–69.
16. C. Wu, T. Shimaoka, T. Komiya, Influence of aeration modes on leachate characteristic of landfills that adopt the aerobic–anaerobic landfill method, Waste Manag. 34 (1) (2014) 101-111.
17. E. Ifrian, B. Galán, A. Andrés, J.R. Viguri, Material flow indicators and carbon footprint for MSW management systems: Analysis and application at regional level, Cantabria, Spain, Resour. Conserv. Recycl. 68 (2012) 54-66.
18. C. Wang, M.D. Lin, C. Lin, Factors influencing regional municipal solid waste management strategies, J. Air Waste Manag. Assoc. 58 (7) (2008) 957-964.
19. S. Chakma, R.C. Vaishya, Assessment of composting, energy and gas generation potential for MSW at Allahabad city in India, Int. J. Res. Eng. Tech. 2 (8) (2013) 210-214.
20. B. Ansah. Characterization of municipal solid waste in three selected communities in the Tarkwa Township of Tarkwa Nsuaem Municipality in Ghana, Kwame Nkrumah University, Kumasi , 2014.
21. A. Pamnani, S. Meka, Integrated solid waste management for municipal solid waste generated from small-scale towns and nearby villages located in a developing country, Int. J. Eng. Res. Gen. Sci. 3 (1) (2015) 596-603.
22. European Environmental Agency, Managing Municipal Solid Waste – a Review of Achievements in 32 European Countries, EEA, Copenhagen, 2013.
23. P. Beigl, S. Lebersorger, S. Salhofer, Modelling municipal solid waste generation: A review, Waste Manag. 28 (1) (2008), 200-214.
24. S. Mor, K. Ravindra, A. De Visscher, R.P. Dahiya, A. Chandra, Municipal solid waste characterization and its assessment for potential methane generation: A case study, Sci. Total. Environ. 371 (1-3) (2006) 1–10.
25. R. Adding, K. Olie, Mechanisms of formation and destruction of polychlorinated dibenzo-p-dioxins and dibenzofurans in heterogeneous systems, Environ. Sci. Technol. 29 (6) (1995) 1423–1435.
26. V.M. Paretsky, V.P. Bystrov, R.I. Kamkin, Physicochemical properties of slags after high temperature treatment of household wastes, Elektrometallurgiya 10 (2010) 36–40.

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