ALUMĪNIJA METĀLLŪŽŅU PĀRSTRĀDES RŪPNIECISKO ATKRITUMU IZPĒTE UN PIELIETOJUMS BŪVMATERIĀLU RAŽOŠANĀ

INVESTIGATION OF ALUMINIUM SCRAP RECOVERY WASTE ON PURPOSE TO PRODUCE BUILDING MATERIALS

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Keywords: Aluminium – alumina containing waste of scrap metal processing, chemical and mineralogical composition, waste stability in different medias

1. Introduction

Along with the entering of Latvia in European Union, more and more attention is paid for waste processing, recycling and utilisation according to the principles of EU stated for waste management [1].

Until now mainly the scientists were paying attention to the industrial waste of Latvia, looking for the different ways of their recycling [2-4]. By introducing mentioned principles in the national economy of Latvia, increased interest from the side of manufacturers could be noticed. Especially it could be attributed to those production unites where large quantities of unprocessed industrial waste are already accumulated. In addition, the amount of waste is increasing according to the augmentation of production dictated by the market.

Production of functional building materials incorporating industrial waste nowadays becomes more and more popular [5-6]. It could be related not only to the cheaper expenses of the production if to compare with adequate products made of new raw materials, but also to the efforts to improve the environmental quality. Along with industrial development the global heating and environmental pollution is becoming more and more actual topic, the utilisation and recycling of industrial waste are set as the priority of each country [7-8]. In many countries the utilisation and recycling of secondary raw materials is subsidised by the state. In this way the natural resources are saved, environmental pollution decreased, more resources for safe storage and management of waste allotted and cost-efficiency of enterprise increased. Building materials produced using industrial waste or by products, subsidised or not by the state, according to their functional properties and resistance to corrosion, have capacity to compete in the market of any country [2-4, 9].

The mixture of metallic aluminium and alumina in the industry of aluminiferous scrap metal processing, is the main by product or waste, which depending on the chemical composition of the mixture, could be successfully utilised in the production of different specific building materials [4, 9].

If initially the aluminium – alumina mixes were suggested to be the remains, the storage of which was unprofitable, hazardous for human health and environment, then currently the largest aluminiferous scrap metal processors have succeeded the find the way how this waste could be utilised, thus generating additional income [4, 9].

The aluminium scrap metal recycling enterprises in Latvia are in specific situation as the scope of scrap processing is relatively small, however large enough to create negative impact to the environment and decrease profitability decline. According to the data provided by aluminium scrap metal recycling companies the amount of accumulated waste is increasing for 12 000 – 15 000 tons per year.

To construct the new, specific and productive factory suitable for manufacturing of building materials utilising just one type of industrial waste, i.e. aluminium scrap metal recycling by products, would be useless from the view point of economics in particular situation of Latvia.

The transportation of waste to appropriate production units abroad would be unfavourable neither. Thus it could be more gainful to create small enterprises producing specific but simple functional building materials according to the demand of Latvian market, dislocated not far from the aluminium scrap metal processing unites.

2. Investigation of aluminium scraps metal processing waste

2.1. Chemical analysis

In order to evaluate more rational mode of utilisation of aluminium scrap processing waste, investigation of chemical and mineralogical composition was carried out. One of the main aspects of interest was the compositional homogeneity or the limits in which occur the changes of chemical and mineralogical composition.

The processing remnants have accumulated during several years. In this time both the raw materials as well the processing technology has undergone changes.

According to the results obtained in chemical analysis, the waste produced 4-5 years ago (during 2002-2003) contains 14.4 % of metallic aluminium and 56.5 % of alumina. Simultaneously the following compounds were detected: Fe_2O_3, MgO, MnO, CaO, CuO, ZnO, SiO_2, TiO_2 etc. (see tab.1.).

Table 1. Chemical composition of aluminiferous scrap metal processing waste, 2002 -2003 (weight %)

Al %	Al_2O_3 %	SiO_2 %	MnO %	CaO %	CuO %	ZnO %	TiO_2 %	MgO %	Fe_2O_3 %	other %
14.4	56.5	15.8	0.12	1.83	0.52	0.85	1.56	0.38	2.1	1.7

Elemental analysis of the processing waste of this period was carried out also by XRF (see tab. 2.).

There is a good correlation between the data derived from chemical analysis (see tab.1.) and XRF (tab.2.) and it indicates that aluminium scrap metal processing waste contains significant amounts of metallic aluminium and alumina during 2002 – 2003. Comparatively in year 2006, processing waste contains 51.7 % alumina and 30.4 % of metallic aluminium (see tab.3). This could be related to the processing technology and raw materials.

According to the results obtained in chemical analysis, the waste produced last years (during 2006) contains significant amounts of metallic aluminium (30.4 %) – twice more compare with oldest waste. Amount of following compounds, which were detected (Al_2O_3, Fe_2O_3, MgO, MnO, CaO, CuO, ZnO, TiO_2 etc.), are similar with previous results (see tab. 1. and 3.). SiO_2 was detected three times less compare with chemical analysis, which was done for waste produced 4-5 years ago (during 2002-2003).

Table 2. Composition of aluminiferous scrap metal processing waste (2002-2003) according to XRF

N^{o}	Element	weight %
1.	Aluminium, Al	31.0
2.	Silica, Si	7.0
3.	Iron, Fe	1.92
4.	Calcium, Ca	1,30
5.	Cuprum, Cu	0.92
6.	Potassium, K	0.63
7.	Zinc, Zn	0.48
8.	Titanium, Ti	0.31
9.	Sulphur, S	0.46
10.	Manganese, Mn	0.11
11.	Nickel, Ni	0.096
12.	Lead, Pb	0.091
13.	Barium, Ba	0.1
14.	Chromium, Cr	0.037
15.	Phosphorous, P	0.06
16.	Chlorine, Cl	0.07
17.	Strontium, Sr	0.01

Table 3. Chemical composition of aluminiferous scrap metal processing waste, 2006 (weight %)

Al %	Al_2O_3 %	SiO_2 %	MnO %	CaO %	CuO %	ZnO %	TiO_2 %	MgO %	Fe_2O_3 %	other %
30.4	51.7	5.2	0.12	1.83	0.41	0.82	1.13	0.38	2.1	1.75

According to the data obtained, the chemical composition of aluminium scrap processing waste can range depending on the time period, when they are proceeding. The remarkable difference of chemical composition could be related to different composition of raw materials and processing technology in different time periods.

2.2. Analysis of crystalline phases of processing waste (XRD)

The mineralogical composition of recent aluminiferous scrap metal processing waste (year 2006) was detected by XRD. Obtained data indicated that the waste contains corundum (Al_2O_3), metallic aluminium (Al), magnesium dialuminium oxide ($MgAl_2O_4$), quartz (SiO_2), iron sulphite ($FeSO_3$), gibbsite ($Al(OH)_3$) and aluminium nitrite (AlN) (see fig.1.). Aluminium nitrite is a compound soluble in water, which in reaction decomposes for gasiform substance with distasteful smell.

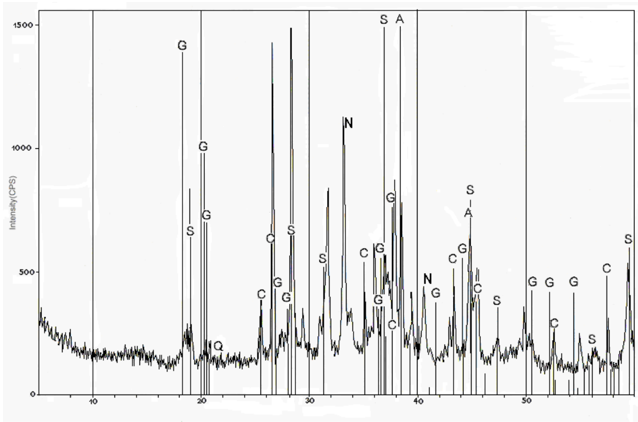

Fig.1. Analysis of XRD for aluminiferous scrap metall processing waste

3. Influence of aluminium scrap metal processing waste to the environment

3.1. Stability of waste in water

In order to evaluate the harm to the environment caused during the storage of aluminium scrap metal processing waste, the deepened investigation of was carried out. Tests related to stability of processing waste in different medias were performed; compositional alterations of waste as well as compounds resulted from chemical transformations detected. For the experiments the latest waste samples were used.

The test incorporates the immersion of the waste samples (100 g by weight) for 28 days in water (1 litre by volume), the analysis of chemical composition of water after that was performed. In this way the storage of processing waste in an open environment as well as the atmospheric and precipitate impact was simulated. Data obtained by analysing the water solution was compared with the factors of quality of potable water (MK Nr. 63, no 23.02.99.).

An elevated concentration of metallic aluminium was detected in obtained water solution (360 mg/l), what for 700 times exceeds the quality factors of potable water (0.5 mg/l) (see tab.4.).

Electro conductivity of obtained water solution (11860 μS/cm) measured according to LVS EN 27888:1993 was exceeded for almost 5 times if to compare with quality factors of potable water (2500 μS/cm) (see tab.4.). Also the amounts of magnesium and copper are exceeded accordingly 8 and 2 times (see tab.4.).

As a result of reaction between aluminiferous scrap metal processing waste and water, significantly increases the pH of examined solution (see tab.4.).

If to compare the pH of water solutions of the waste from 2002-2003 and 2006, significant difference in pH was not detected. The values of pH for water solutions are in the range from 6 to 7 (year 2002-2003 and year 2006) (see tab. 5.).

Together with the development of processing the waste contains more water soluble alkaline compounds if to compare with previous years. Amount of chlorides increase from 0.03% to 1.65%, but amount of sulphates from 1.22% to 2.29% (see tab.5.).

Table 4. Solubility of aluminium scrap metal processing waste in water (samples of year 2006)

Determined parameter	Unit	Testing results
Electro conductivity	µS/cm	11860
Hardness	mmol/l	0.74
Iron, Fe	mg/l	0.2
Aluminium, Al	mg/l	360
Calcium, Ca	mg/l	22
Magnesium, Mg	mg/l	4
Cuprum, Cu	mg/l	4.15
Zinc, Zn	mg/l	0.22

Table 5.Water solubility of aluminium scrap metal processing waste (year 2002-2003 and 2006)

Determined parameter	Unite	Testing results Year 2002-2003	Testing results Year 2006
pH	pH unit	6.2	6-7
Chlorides	%	0.03	1.65
Sulphates (K, Na)	%	1.22	2.29
AlN (decomposes)	%	0.22	0.22

Aluminiferous scrap metal processing waste reacts with water, in the reaction the gasiform staff is desorbed with smell similar to ammonia. According to the tests carried out the waste of different periods contains AlN, which reacting with water decomposes.

In order to identify the possible air pollution at the place of storage of processing waste as well as the chemical composition of the gaseous substance originating in reaction between waste and atmospheric moisture. The chemical analysis of gaseous substances indicates the presence of n-butanole with the concentration of 0.068 µmol/mol. Thus the environmental pollution unfavourably influencing the quality of air in the populated area is detected.

3.2. Waste stability in acidic media

In order to evaluate the stability of aluminiferous scrap processing waste in the acidic environment the test was carried out according to the methodology described by LVS ISO 10566:1994, when the sample of 100 g for 28 days is kept in 3% HNO_3 solution (1 litre). The chemical composition of solution was analysed. According to this test method the storage of waste in a condition of polluted environment was simulated and the waste stability in acidic or polluted environment evaluated.

Table 6. Results of chemical analysis of the aluminiferous scrap processing waste dissolved by acidic media (HNO_3) (year 2006)

Determined parameter	Unit	Testing results
Aluminium, Al	g/l	42.4
Calcium, Ca	mg/l	<2.5
Magnesium, Mg	mg/l	<2.5
Iron, Fe	mg/l	0.08
Zinc, Zn	mg/l	150
Cuprum, Cu	mg/l	59.1
Plumbum, Pb	mg/l	30
Hardness	mmol/l	<0.05

Heavy metals were determined in the analysed solution. Concentration of aluminium, Zinc, cuprum, plumbum and iron were noticeably increased (see tab. 6.). It means that pollution of the environment will be done in the acid media in the case than aluminiferous scrap processing waste will be stored in the untreated way.

3.3. Waste stability in alkaline media

In order to evaluate the stability of aluminiferous scrap processing waste in the alkaline media the test was carried out according to the methodology described by LVS ISO 10566:1994 - the sample of 100 g for 28 days was kept in 3% KOH solution (1 litre). Chemical analysis was performed for obtained solution. According to this test method the storage of waste in conditions of polluted environment was simulated and the waste stability in alkaline media appearing during storage in a reaction between waste and atmospheric or ground water evaluated (see tab.7.).

Table 7. Results of chemical analysis of the aluminiferous scrap processing waste dissolved by alkaline media (KOH) (year 2006)

Determined parameter	Unit	Testing result
Aluminium, Al	mg/l	118.3
Calcium, Ca	mg/l	<2,5
Magnesium, Mg	mg/l	<2.5
Iron, Fe	mg/l	<0.02
Zinc, Zn	mg/l	0.02
Cuprum, Cu	mg/l	0.42
Plumbum, Pb	mg/l	0.0042
Hardnes	mmol/l	<0.05

Due to the action of alkaline media harmful substances from scrap processing waste was derived. Concentrations of harmful substances are high enough to influence the quality of environment and cause the harm to human health. This also improves that the waste could not be utilised as filler for building materials with alkaline binder without special treatment.

4. Conclusions

Chemical and mineralogical composition of aluminiferous scrap metal processing waste changes depending on processing technology and time period.

Before application of waste for the production of new building materials, it is necessary to carry out the waste treatment or refinement in order to obtain raw material with invariable chemical and mineralogical composition, and stability in the alkaline media.

Continuous storage of aluminiferous scrap metal processing waste is not acceptable, as the environmental quality is affected by increased water and air pollution.

If during the production of building materials acidic media is created, aluminiferous scrap metal processing waste is no applicable as the ingredient.

I will be necessary to continue investigations in the field of waste treatment and refinement order to use them in the industry of building materials.

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Bajāre D., Rozenštrauha I., Krāģe L., Korjakins A. Alumīnija metāllūžņu pārstrādes atkritumu izpēte un pielietojums būvmateriālu ražošanā

Metāliskā alumīnija un alumīnija oksīdu maisījumi alumīniju saturošu metāllūžņu pārstrādes rūpniecībā ir viens no galvenajiem blakusproduktiem jeb atlikumiem, kurus, atkarībā no maisījuma ķīmiskā sastāva, veiksmīgi iespējams izmantot dažādu specifisku būvmateriālu ražošanā. Lai noskaidrotu ražošanas atlikumu lietderīgas izmantošanas iespējas, veikta to pastiprināta izpēte un salīdzināti dati, kuri iegūti veicot ķīmiskā sastāva izpēti 2002.-2003. gada un 2006. gada ražošanas atlikumiem. Papildus pētīta šo atlikumu ietekme uz apkārtējās vides kvalitāti, veicot pārbaudes, kuras raksturo to noturību dažādās vidēs – neitrālā ūdens vidē, 3% KOH šķīdumā un 3% HNO_3 šķīdumā.

Bajare D., Rozenstrauha I., Krage L., Korjakins A. Investigation of aluminium scrap recovery waste on purpose to produce building materials

Metallic aluminium and alumina mixture is one of the main by-products or waste in aluminiferous scrap processing industry. Depending on the chemical composition, the mixture of aluminium and alumina could be applied in the production of particular building materials. In order to evaluate the effectiveness of mentioned, deepened investigation was carried out. The chemical composition between waste produced in 2002.-2003. and 2006. was compared. Applying different tests, the influence of given waste to the environmental quality was studied, by characterising their stability in neutral (pure water), alkaline (3 % KOH solution) and acidic (3% HNO_3) medias.

Баяре Д., Розенштрауха И., Краге Л., Корякин А. Исследование промышленных отходов переработки алюминиевого лома с целью их использования в производстве стройматериалов

Смеси металлического алюминия и оксида алюминия являются одними из основных побочных продуктов или отходов при промышленной переработке алюмосодержащего лома, и могут быть успешно использованы, в зависимости от химического состава смеси, для производства различных специфических строительных материалов. Углубленное исследование и сравнение данных химических анализов было проведено для промышленных отходов, полученных в 2003-2003 и 2006 г., чтобы оценить возможность их практического использования. Дополнительно исследовано воздействие алюмосодержащих отходов на окружающую среду посредством экспериментов, характеризующих устойчивость смесей в различных средах: нейтральной водной, в 3% растворе KOH и в 3% растворе HNO_3.