USE OF WASTES FROM ENERGY INDUSTRY IN BUILDING MATERIAL INDUSTRY – A PROOF OF CIRCULAR ECONOMY CONCEPT

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ABSTRACT: Products designed in a circular way can minimise resource use and foster materials reuse, recovery and recyclability. The coal ash represents an important industrial waste source. The reuse and recycling of coal ash is ours concern for a long time. In this paper it will be present some possibilities of building materials manufacture using different percent of coal ash in its composition. On the industrial flow were tested the different compositional variants with 5%, 10 % and 15 % of coal ash an one compositional variant with 20% sand, that was used as reference elements. The bricks were characterised in term of geometric density, compression strength, apparent density, absorption capacity, open porosity.

KEY WORDS: coal ash, eco-bricks, reuse, recycling, circular economy.

INTRODUCTION

In December 2015, the European Commission adopted a Circular Economy Action Plan [1] to give a new boost to jobs, growth and investment and to develop a carbon neutral, resource-efficient and competitive economy. The 54 actions under the action plan have now been completed or are being implemented, even if work on some will continue beyond 2019 [2].

In Europe, recycling of municipal waste during the period 2008-2016 has increased and the contribution of recycled materials to the overall materials demand shows continuous improvement [2]. However, on average, recycled materials only meet less than 12 % of the EU demand for materials [2]. This is echoed by a recent stakeholder report suggesting that full circularity would apply to only 9% [3] of the world economy, leaving vast areas for improvement.

In according with circular economy concept our research works were focused on reuse of industrial wastes in industry that conduct to obtain a new product, new markets, and, of course new jobs (figure no.1). Also, the environment protection was not disregarded, because on the one hand reuse and recycling waste leads to save a valuable natural resources and on the other hand will be reduce the cost on industrial works to storage of these industrial wastes.

Figure no. 1 Circular economy [4]

In these paper will be present an concrete example of reuse of energy industry waste (bottom ash) in building industry (burnt bricks).

The basic raw material to manufacture of building bricks is grey clay that is recovered from excavation works related to the exploitation of lignite in open mining pit (clay from Rosia mining pit) [5, 6].

In the situation when the clay supplied has a too high plasticity parameter, on the technological flow of building bricks it is probably to appear structural defects after drying and/or burning processes. These structural defects are manifested as nonconforming cracks or deformations, and products that has these structural defects are rejected.

In these situation the plasticity parameter are reduce by use natural aggregates such as sand with the grain distribution (0-4) mm as degreasing agent (technic term that defines the addition of granular aggregate).

The paper present the results of industrial researches that were carried out within the project *Use of waste from extractive, energy and metallurgical industries as sources of raw materials to manufacture of thermal insulation refractory products and building materials UCBECOTECH, MySMIS Cod 105628* [7].

The aim of industrial researches within the project is to establish the way to replace the Quartzite sand that is usually use to reduce the plasticity parameter with thermal power plant ash (bottom ash) [7].

In term of chemical composition between three types of raw materials that are use in composition of bricks that are made of burnt clay, can to find some aspect of similarity and the different too, as is presented in the table no. 1.

Table no. 1 Oxide composition of raw materials

Raw material	Basic oxide compounds (%, mass)					
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O+K_2O
Clay from Rovinari	63 - 68	14 - 17	5 - 6	0,8 – 1,1	1,5 – 1,8	4 – 4,5
Quartzite sand	85 - 89	4 - 5	2 - 3	1,5 – 2,5	0,4 - 1	1,7 – 2,2
Bottom ash Rovinari	40 - 50	16 - 21	8 - 9	9 - 14	2 - 3	1,5 - 3

Taking into consideration the oxide composition that are presented in table no. 1, from the compositional point of view, the degree of compatibility of the components in the shaping mixture will remaining practically identic, after sand replace with bottom ash. Also, the maximum level of temperature in the burning phase remaining unchanged.

In term of physical characteristics, between two raw materials that are using as degreasing agent in shaping mixture there are important differences (table no. 2, table no. 3, figure no. 1).

Table no. 2. The moisture and bulk density of sand and bottom ash

Raw materials	Moisture (%)	Bulk density (g/cm^3)	
		Netasat	Tasat
Quartzite sand	15 - 17	1,50 – 1,60	1,60 – 1,70
Bottom ash Rovinari	22 - 27	0,75 – 0,80	0,88 – 0,94

Table no 3. Particle size distribution for sand and ash samples

Sample	Rest on the sieve %, mm								
	4	2	1	0.5	0.25	0.125	0.09	0.063	<0.063
Sand	0.03	11.94	22.20	29.16	21.29	9.05	2.80	1.84	1.69
Bottom ash	0.00	2.10	4.12	9.19	17.89	24.20	11.44	8.74	22.32

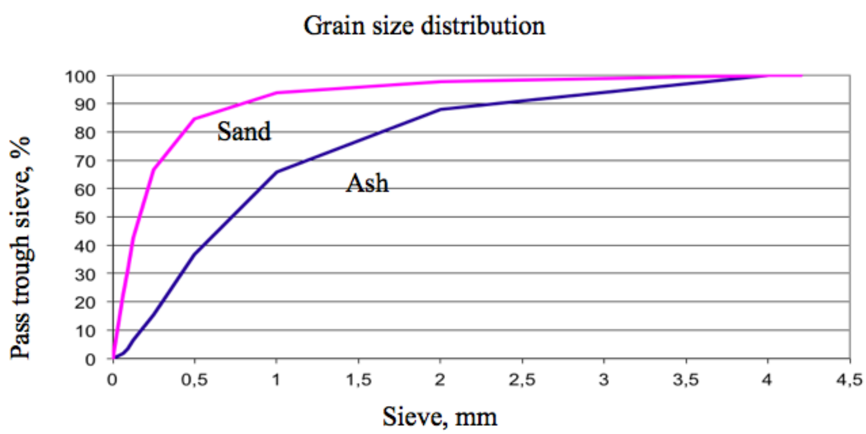

Figure no. 1. Grain size distribution of sand and bottom ash

From point of view of technological application, the differences of physical characteristics mentioned above will have not the major influences, due to:

- the final moisture of shaping mixture will be assure through water correction in mixture components stage.
- the dimensions of mixture component' particles are reduce through successive pass through roller mills (coarse and fine) such that to the end will obtain the homogenous mixture with grain size under 1 mm.

Also, the chemical oxide composition of ash from Rovinari is presented in table no. 4.

Tabel no. 4. The chemical oxide composition of ash [2]

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	P.C.
65,80	0,68	15,97	5,40	0,11	1,64	0,85	1,86	2,37	0,12	5,35

The quality of finite product (burnt bricks) is influenced by the clay plasticity parameter. The value of clay plasticity parameter varies into large domain which is likely to cause real problems in the flow of bricks, including in plastic extrusion technology.

Usually, the optimum plasticity parameter value for moulding on the snail press is 26-28. When the plasticity parameter exceed 30 units, its are expected cracks after drying and burning.

It turns out that the determination of clay plasticity during manufacture of lots of products is un important element.

EXPERIMENTAL

Experimental works were realised on the industrial flow of SC MACOFIL SA. In order to identify of best solutions, were tested 3 compositional variants:

- an experimental lot with 5% bottom ash percent, 7,58 tons mixture, approximately 3 m^3 final burnt product,
- an experimental lot with 10% bottom ash percent, 8 tons mixture, approximately 3,5 m^3 final burnt product,
- an experimental lot with 15% bottom ash percent, 8,5 tons mixture, approximately 4 m^3 final burnt product.

From the experimental lots obtained on the industrial flow of SC MACOFIL SA were extracted the elementary sample that were characterized within the Physic – Mechanic Tests Laboratory of Constantin Brancusi University of Targu Jiu).

In order to realise a correct comparison, were taken bricks from current production that has use the sand as degreasing agent with 20% percent.

The samples were subject of geometric density, compression resistance, apparent density, absorption capacity and open porosity tests. The results are presented in table no. 5.

Table no. 5. Physical-mechanical characteristics of products (average values)

Sample	Geometric density g/cm^3	Compression resistance MPa	Apparent density g/cm^3	Absorption capacity %	Open porosity %
N	1,62	30,88	1,84	15,69	28,85
C5	1,68	21,03	1,73	19,69	34,06
C10	1,70	34,17	1,75	18,31	31,95
C15	1,65	23,19	1,70	20,30	34,49

N - elementary samples of bricks from current production with 20% sand addition,

C5 - elementary samples of experimental bricks with 5% bottom ash addition,

C10 - elementary samples of experimental bricks with 10% bottom ash addition,
C15 - elementary samples of experimental bricks with 15% bottom ash addition.

CONCLUSIONS

The value of a circular economy approach is recognized, today, not in the European Union, but also worldwide. All the international institution highlighted the economic and environmental advantages of such an approach. And, also, all of us agree that circular economy is a one way to sustainable development and reduce a carbon footprint.

In this regard the wastes from extractive industry (grey clay) and from energy industry (bottom ash) can be used to building industry in order to manufacture of burnt bricks.

The waste of energy industry are valuable in term of chemical and mineralogical composition and can be a raw materials for other industry.

In this paper was presented only one way to reuse this waste in building material industry.

The raw materials that were used presented some specific aspects in term of physical characteristics, and from this reason results as necessary realize of laboratory tests for each industrial bricks lot:

- for clay from Rovinari plasticity determination is necessary,
- for bottom ash are necessary: moisture, bulk density, grain size distribution determinations.

In order to obtain a high level of mixture homogeneity is recommended a preliminary stage of mixing of the components (clay and ash), on the ground, with suitable mechanical equipment.

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