THERMAL POWER PLANTS SLAG AND FLY ASH – WASTES WITH HIGH REUSE POTENTIAL

PROF.UNIV.DR.ING. LUMINIŢA GEORGETA POPESCU,
CSII Chem. TRAIAN ALEXANDRU ABAGIU
CSIII ADELA BANCIU

University "Constantin Brâncuşi", Tg-Jiu, ROMANIA

ABSTRACT: By burning coal in thermal power plants in Romania, results large waste quantities which can be grouped into fly ash, powdery material, collected from the flue gases through electrostatic precipitators, mainly used as additive in the cement industry and bottom ash, a mixture of slag and heavy ash which collects at the bottom of the boiler and is discharged through the transport system to the ash and slag deposits. Slag and ash develop soil deposits which generate large environmental problems, being a source of groundwater and surface pollution of soil, due to large surfaces occupied and also a source of air pollution due to the ash particles entrained by the wind. Moreover, slag and ash deposits affect biodiversity because of pollutants contained in these wastes (especially heavy metals). For these reasons, and also for natural resources preservation, through different research technologies were analyzed diverse possibilities for reusing of such thermal power plants wastes, given the physical, chemical and mineralogical characteristics.

KEY WORDS: ash and slag, bottom ash, fly ash, reuse, thermal power plant

1. SLAG AND ASH GENERATION IN THERMAL POWER PLANTS FROM OLTENIA

In case of power plants from Oltenia, the amount of ash which is produced is very high due to increased ash content (about 30%) in burned lignite. The average characteristics of lignite from Oltenia Region are indicated in Table 1 [1]. The burn of fossil fuels is associated with the generation of a variety of residues and secondary products.

The term of secondary product is generally used for materials that can be sold on market (for example the gypsum resulted from flue gas desulphurization flow).

According to their provenience, the residues from the burning installation can be directly divided in wastes corresponding to the burning process or wastes generated from the exploitation of the installation and its equipment as the coal mills or the water treatment units [2,3].

During technological process of coal combustion in boilers, ash results separately. Ash contains fine particles with diameters less than 0.25 mm (also called fly ash, as is easily driven by wind).

It leaves the burning chamber in the same time with the combustion gases, being partially retained and collected in the funnels, which are located under the air preheaters, and in the funnels of the flue.From the funnels, the ash is driven by free fall through large diameter pipes (400 mm or 600 mm) with high slope to the ground level, where it is mixed with water and then is disposed to pumps station for sludge.

Bottom ash (known as slag) consists of particles having size of 0.25 – 1mm or more.

Table no. 1. The average characteristics of lignite [1]

Parameter		Value [%]
Adventitious moisture content		36,21÷43,21
Inherent moisture content, AR		3,18÷5,45
Total moisture content		41,35÷46,29
Ash content, AR		13,6÷25,29
Ash content, DB		25,12÷43,12
Sulfur content	Combustible, AR	1,09÷1,42
	Total	1,26÷1,72
Nitrogen content, AR		0,49÷0,65
Oxygen content, AR		7,03÷8,85
Carbon content, AR		21,98÷25,86
Lower heating value		6,92÷9,06
Volatile matter content		15,25÷21,19

The slag resulted from burning lignite of each boiler of 1036 t/h of thermal power plants of Oltenia is crushed and hydraulically transported, by channels to pumps station.

The Bagger pumps stations ensure the transport of the ash and slag hydraulic mixture (ash/water = 1:8...1:10) and disposal to the deposit. Currently, heavy ash cannot find an economic use in Romania, now constituting within the category of non-dangerous industrial waste category. However, the diverse chemical, mineralogical and morphological properties of ash offer an opportunity to process it and recover various fractions with particular attributes [4,5].

2. POTENTIAL USE OF TARGETED INDUSTRIAL WASTES

Within the project LIFE 10 ENV/RO/729 - New building materials by eco-sustainable recycling of industrial wastes, ECOWASTES were studied several possibilities for bottom ash recovery, alone or in combination with other wastes generated by other industries, given the characteristics similarity of these wastes with some natural raw materials used in current industrial flows of manufacturing building materials [5]:

- **heavy ash** arising from Valea Ceplea Deposit of Turceni thermal power plant can be assimilated with a slightly granular aggregate, similar to a clay-limestone quartz sand, but exhibiting a bulk density lower by 20-25%, and was used as a replacement, both as a degreaser role in molding mixtures of clay-based materials and as aggregate in mixtures masses and concrete with cold hydraulic hardening;

- **oil drilling sludge** resulting from drilling activities in geological layers Dacian and Pontian from the southern and south-eastern Romania, characterized as a mixture of marl and loamy sands, has the property to ensure the feasibility of molding mixtures and was used as plasticizer for obtaining composites through the process of pressing, followed by high temperature ceramic bonding (sintering);

- **metallurgical slag of the steel making** in the electric arc furnace (EC slag), after primary processing by crushing and calibrated granulation, can successfully replace natural granular aggregates, both in the production of pressed and burned (bricks) and in the manufacture of concrete with hydraulic strengthening;

- **metallurgical slag of the secondary treatment** of liquid steel (LF slag), after primary processing by crushing and fine grinding, presents hydraulic cold hardening property and can be used as an additive binder for obtaining molding mixtures through casting-vibrating or stamping-ramming (mixtures and concrete) [5].

The ash taken from historical deposits of power plants from Oltenia can be used in the manufacture of mixtures or concrete obtained by direct molding. In case of the manufactured molded products by pressing or vibropressing and the concrete obtained by spraying, in which the continuity of particle size distribution have a high degree of importance, the fly ash needs to be processed by sieving, which ensure elimination of agglomerates and traces of slag larger than 5 mm. For using, the ash does not require pre-drying [6].

Main owner of ash deposits in large amounts for large-scale results application (about 20 million tonnes in a single deposit compartment), representative of all similar deposits generated by the major manufacturers of electricity based on lignite from Oltenia region is the Energetic Complex of Oltenia - Thermoelectric power plant Turceni.

Given the consistency of origin source (burning lignite from the Oltenia region), fly ash exhibits variations in physical and chemical parameters within limits that are not capable of influencing the usability as alternative raw material for manufacturing technologies of building materials proposed in this feasibility study [6].

The oil drilling sludge may be used as component with a plasticizer effect for molding mixtures, as resulting after separation by advanced sieving (< 0.1 mm) of large fragments of debris (crushed rock) and excess removal of drilling fluid by centrifugation.

Centrifuged oil drilling sludge can be used as resulted in the process of extraction from its source (drilling points), after transport and storage conditions that preserves moisture and specific colloidal constitution (plastic containers with lids). In situations where high sludge humidity is an impediment, it can be dried and ground.

The oil drilling sludge is an industrial waste, generated in the geographical areas were drilling takes place. Laboratory tests carried out have confirmed that for all sludge resulted from drilling at depths exceeding 600 meters (Dacian and Pontian geological layers) in the south of Romania, physico-chemical and mineralogical features show high similarity.

This finding leads to the natural conclusion of suitability for use, in the new technologies developed within the project LIFE 10 ENV/RO/729 - New building materials by eco-sustainable recycling of industrial wastes, ECOWASTES, of sludge resulted from such activities, irrespective of drilling position, but under specific conditions imposed by the project area of investigation: Dacian and Pontian detritus layers, technology - water based drilling fluids and using as densification material calcium carbonate (limestone filler) [6].

Gray greasy clay from Rovinari may be used as extracted from lignite open pit of Rosia Jiu and used in the production of molding plastic mixtures, if the manufacturing technological process has equipment capable of directly homogenize mixtures containing mainly raw material (mixer drums, double helix ribbon mixer). In other situations, such as in the case of products manufactured by molding semi-plastic material or semi-dry mixtures, prior is required natural drying followed by fine grinding (< 0.5 mm).

Clay must come from a place where it was stored in covered space and after natural drying up to the stage that allowed the grinding using pebble mill, up to a maximum particle size of about 0.5 mm [6].

Considering gray clay, resulting from the rock scraping from lignite quarries, as a waste of the mining industry, it can be considered that manufacturing new types of materials, using the processes of hot bonding can be achieved exclusively by using as raw materials of industrial waste: thermal power plant ash, sludge oil drilling, clay [6].

The necessity of primary wastes processing, depend either on the conditions in which are obtained,

either due to specific requirements under which are used as raw materials in further technologies.

The main types of required processing are crushing/grinding, sieving (sorting on dimensional fractions), drying and fine grinding (figure no.1).

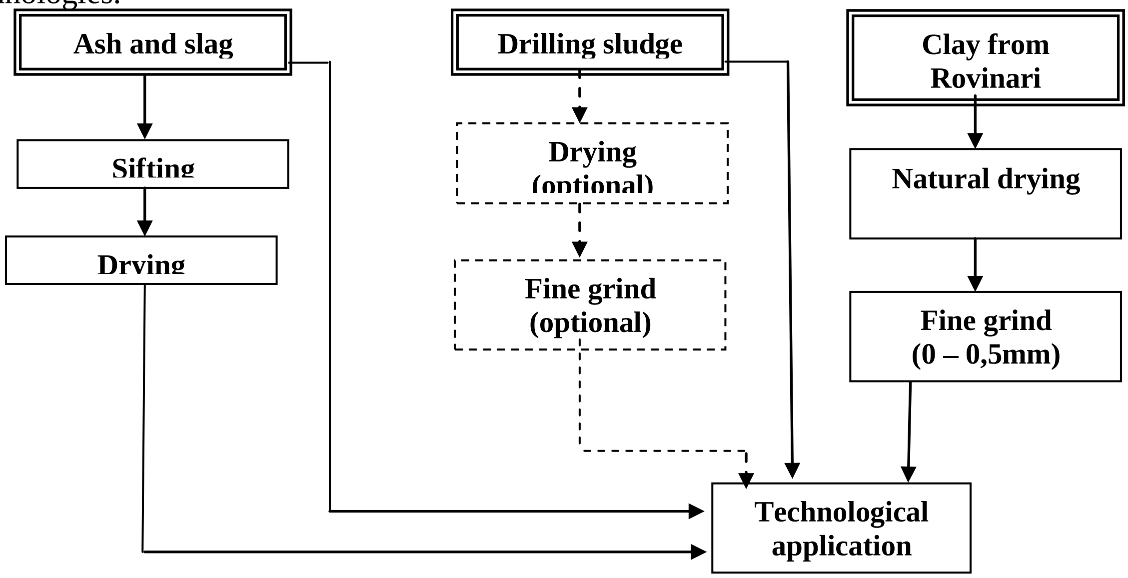

Figure no 1. The flowchart of the primary processing of waste flow

3. DISCUSSIONS AND CONCLUSION

Pilot experimental work regarding the use of industrial wastes for obtaining products by pressing technology, developed in the project LIFE 10 ENV/RO/729 - New building materials by eco-sustainable recycling of industrial wastes, ECOWASTES, aimed at establishing possibilities for the usability of power plants ash, sludge oil drilling and metallurgical slag on technological flow dedicated for bricks manufacturing, taking into account in this regard the two main molding techniques used in targeted industry.

Experiments on industrial flows, conducted by the economic agents within the project LIFE 10 ENV/RO/729 - New building materials by eco-sustainable recycling of industrial wastes, ECOWASTES allowed the application of manufacturing technologies for the building materials developed during the research activities and micropilot laboratory stages [7].

Industrial applications have verified the possibilities of obtaining building materials from alternative raw materials of thermal power plant ash, sludge oil drilling and metallurgical slags. Experiments were carried out taking into account the classical application methods for obtaining three major categories of building materials:

a. Products obtained by hot bonding: pressed and burned bricks;

b. Products obtained by cold bonding: bricks, concrete blocks, curbs and paving pressed and vibropressed;
c. unmolded products: ramming mixtures, mortars and concretes
Experimental results confirmed the possibilities of using studied wastes and specific features that are induced in obtained products:
a. The ash – a decrease in density and an increase in the products porosity or an increase in thermal and acoustic insulation capacity (figure no. 2, 3);

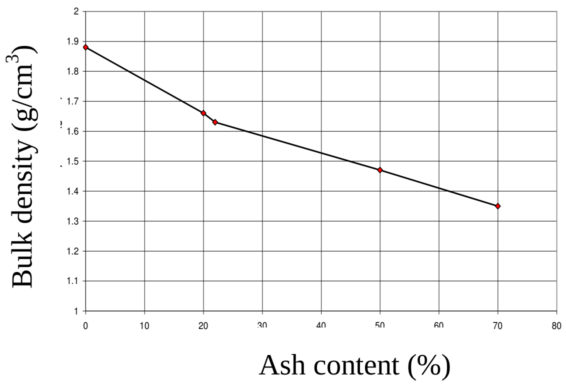

Figure no. 2 Bulk density dependency on the mixture ash content [7]

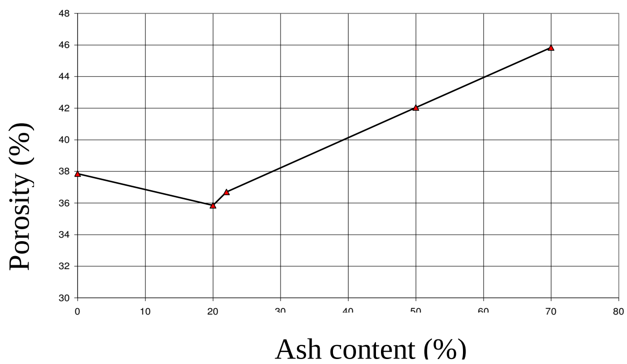

Figure no. 3 Porosity dependency on the mixture ash content [7]

b. Sludge oil drilling - similarity with usual feldspathic clay, in order to ensure plasticity of molding mixtures and contribution in shaping and developing the structure strength as ceramic binder;
c. Steel making clay - dense granular aggregate, ready for use in the manufacture of molding mixtures to obtain leveling and form layers and the production of dense concrete;
d. Slag of the secondary treatment of steel - waste with high content of free calcium oxide (lime) and calcium silicates, ready to partially replace the conventional hydraulic binders to obtain molding mixtures.
Manufacturing technologies for building materials using studied industrial waste, it is necessary to follow some specific work requirements, determined by the characteristics of such wastes:
a. The ash can be used for manufacturing of pressed and sprayed concrete after removing parts of slag by sieving at the maximum size of 5 mm
b. Electric furnace slag needs to be primarily processed by crushing and granulation until a granular bulk aggregate is obtained with maximum grain size of 10 mm
c. Slag secondary treatment is recommended to be fine grinded below 0.1 mm with the aim to obtain optimal properties of hydraulic binder.

Manufacturing technologies with hot bonding are recommended to be applied in order to obtain building elements, pressed and burned, from semi-dry mixtures, semi-plastics and plastics containing 20-70% fly ash. For semi-dry and semi-plastic mixtures it is recommended molding by static shaping press, while for molding plastic mixtures is recommended press-screw extrusion.

Molding by vibropressing of bricks with cold-hardening (based on hydraulic binder) offers the possibility of obtaining products containing 70% ash, having densities with 25-30% lower than conventional burned bricks, under the classification in the same category of mechanical strength.

In case of curbs and pavament production, application of the static pressure process in the mold ensures the possibility of operating with semi-dry mixtures containing high percentages of electric furnace slag (40-60%) and can confer high resistance to abrasion of finished products.

The ash can be used as light granular aggregate for heat-resistant and heat-insulator concrete manufacture with grades of density from 0.8 to 1.1 g/cm^3 and maximum working temperatures of 850 ˚C and 1150 ˚C, depending on the nature of hydraulic binder (silicon and calcium based cement or aluminum and calcium based cement) [7].

Acknowledgements

The present research has been carried out with the financial support given through LIFE10 ENV/RO/729 Project.

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