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Effect of firing temperature on the structure of the aggregate from sintered ashes

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Abstract

Production of artificial aggregate from ashes is worldwide known technology that uses up to 100% of ash in the mixture. There are known two types of aggregate. First is based on binders and known as cold-bonded. Second type of aggregate is produced by self-firing process that uses a content of combustible substances in the mixture. After ignition this fuel generates enough energy for the sintering process. The paper gives an account of the influence of parameters of ash and conditions of firing on the quality of ceramic body made from ash. Temperatures of 1050 °C, 1150 °C and 1200 °C were examined. The research focused on the structure of the ceramic body as well as its physic-mechanical parameters. The results show also that firing temperature is essential for forming the structure. An important indicator is the share of melt that form a solid ash body.

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Keywords: Artificial aggregate; fly ash; FCB ash; sintering; clinkering

1. Introduction

European and world trends in new technology development in the building industry make a sustained pressure on provision of production of quality light artificial aggregates, its application has a rising trend namely in advanced countries [1,2].

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Only Poland (in Central and Eastern Europe) reacted to this trend by construction of a factory for artificial aggregate production from sintered fly ash in Gdansk. The factory is equipped by license process equipment from Lytag, UK. However, the technology level of this production process is even older than the Corson technology [3].

The production technology of artificial aggregates made by burning are frequently operated in original format using quality black coal fly ash containing optimal amount of unburned residues and without necessary correction of the fuel substances in the mixture or the aggregate is burned by the external heat source [4].

There is no competition within this field in the world and thus the involved companies do not dedicate to development and innovations. On that ground the questions of artificial aggregates from sintered fly ash are relatively lowly explored. There are also only minimum scientific works dedicated to the process of production of fly ash body creation at burning. Therefore if we consider the possibility to restoration of the production in domestic conditions it is necessary not only to innovate the existing technology but also in particular to dedicate to study of reaction processes in solid phase and creation of fly ash aggregates [5].

2. Materials and methods

In the beginning, experimental activity was focused on the characterization of selected types of ashes, representing current production plants of the Czech Republic. There were following samples selected: fly ashes produced by high temperature combustion of brown coal as well as ashes from fluidized bed combustion of brown coal. It is necessary to repeat that high temperature ash are produced during combustion of minced coal at temperatures of 1200 – 1600 °C, desulphurization takes place after separators by using the lime solution. Fluidized bed combustion takes place at temperatures around 850 °C; desulphurization is located directly in the furnace by combustion of the lime together with coal.

Fly ashes from brown coal are represented by two samples (FA1, FA2). Ashes produced by fluidized bed combustion of brown coal are represented also by two samples (FBC1, FBC2).

2.1. Physico-mechanical and chemical parameters

Physic-mechanical and physic-chemical parameters are very important for basic evaluation of ashes. Following parameters were selected: loss on ignition, bulk density, specific surface area, rest on the sieve 0.063 mm and chemical composition. Following tables shows test results of individual samples of ashes.

Table 1. Physico-mechanical and physico-chemical parameters of tested ashes.

Samples	Loss on ignition (%)	Bulk density ($kg \cdot m^{-3}$)	Rest on the sieve 0.063 mm (%)	Specific surface ($m^2 \cdot kg^{-1}$)
FA1	1.1	1110	42.9	299
FA2	1.9	1010	62.4	234
FBC1	2.1	640	33.7	361
FBC2	2.0	770	47.6	353

Table 2. Chemical composition of tested ashes.

Samples	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	SO_3 (%)	CaO (%)
FA1	54.60	29.50	5.46	0.08	1.81
FA2	50.00	23.40	14.50	0.26	3.42
FBC1	27.60	17.50	5.63	7.57	30.40
FBC2	42.70	26.80	5.05	2.98	10.20

All samples fulfill the requirement of the standard CSN 72 2072-6 [6] for maximal loss on ignition (15%). Determination of bulk density shows that fly ash from high temperature combustion reach higher values than ash from fluidized bed combustion. All values of high temperature fly ash samples fulfill the requirements of the Standard CSN 72 2072-6 [6] for minimal value of shaken off bulk density 800 $kg \cdot m^{-3}$.The finest ash is the FBC1. In