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Comparison of separate and co-grinding of the blended cements with the pozzolanic component

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Abstract

The main difference between separate and co-grinding of blended cement is the fact that co-grinding occurs interaction among the milled components. These interactions may speed up milling process, or on the contrary to slow it down. It depends on grindability of the components. Separate grinding and subsequent homogenization is more common. High speed disintegrator appears to be a promising technology for the homogenization of blended cements after separate milling process in traditional mills, which can be associated with final grinding. The aim of the work was to compare the effect of separate and co-grinding, and their combinations on the properties of the blended cement. At first the samples of pure glass, pure Portland cement and its mixture were pre-ground in the ball mill to the specific surface area of 400 m^2/kg according to Blaine. The material was subsequently ground either in a ball mill or disintegrator by the various combinations of separate or co-grinding. All the samples were subjected to granulometric and morphological analysis and the analysis of the technological properties. In the case of the combination of cement and glass the co-grinding appeared to be more advantageous than the separate grinding with homogenization. The high speed disintegrator has produced sharp-edged grains with narrower particle size distribution curve than traditional ball mill. Technological properties of the cement have been also influenced by high speed disintegrator. Compressive strength in early age was higher than in the case of ball mill type cement, however, the final strength were essentially the same.

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1. Introduction

Secondary raw materials represent an ever more frequent replacement for primary raw materials in the production of cement. In current practice the Portland clinker is replaced by hydraulically active compounds or agents with pozzolanic properties [1,2]. Glass is chemically and mineralogically very close to traditional pozzolans and various authors have described the behavior of finely ground glass in cement composites [3,4,5]. However, due to considerable ability to agglomerate, the recycled glass is not usually enough reactive and acts only physically-mechanically as a filler [4]. A common production process of the blended cements is separate grinding of the individual components and their subsequent homogenization. This procedure is very common especially when blast furnace slag is used. And it works in this case, because Portland cement clinker and blast furnace slag have very different grindability and it is therefore preferable to grind them separately, and subsequently to homogenize [6]. As noted above, fine glass powder exhibits significant ability of the aggregation, which greatly complicates homogenization with the Portland cement. Therefore, the traditional approach of separate grinding and subsequent homogenization seems to be less suitable in the case of glass-cement system. An interesting option to prevent the formation of agglomerates with pure glass is co-grinding of the glass and clinker because the grindability of both components are very similar [7]. But the question is if this income brings any benefits to final cement properties than separate grinding and subsequent homogenization.

2. Materials and methods

The laboratory-prepared blended cement was used to compare the effects of a separate and co-grinding of the final cements properties. The samples of the blended cement should always have the same composition. The ratio between the components were 80 wt. % of Portland cement and 20 wt. % of the pozzolanic ingredient. The recycled glass was used as a pozzolanic ingredient. Portland cement was prepared also in the laboratory from the Portland cement clinker at a dose of 95 wt. % and from gypsum PREGIPS at a dose of 5 wt. %. Five samples of the blended cement by different technology of separate and co-grinding were prepared in total.

The jaw crusher Retsch with the size of the exit slit 3 mm and two types of mills were used to samples preparation. The laboratory ball mill OM BRIO 20 was used as the primary mill. Mill rotation frequency was 45 rpm. The secondary mill was the disintegrator DESI 11, which is a high speed pin mill with two counter-rotating rotors. The total installed output of the mill is 4.1 kW. Rotor rotation frequency is up to 12000 rpm and maximum speed of impact is 240 $m \cdot s^{-1}$. The material is fed by a continuous feeder and enters the grinding chamber through the middle of the left rotor. The construction of mill allows for choice of working tools. For the evaluation of milling process, CR type rotors were used. The rotors were designed and manufactured by the company FF servis s.r.o. The left rotor has two rows of pins and right rotor has three rows. The pins have a square cross section. The raw material for the blended cement production was ground in a jaw crusher at first and subsequently was milled in a ball mill to achieve specific surface area of 400 $m^2 \cdot kg^{-1}$ according to Blain. Cement components were ground together and separately as well. Three of the five samples were then ground by one pass through the mill DESI 11. Remaining two samples were then ground in a ball mill to achieve the same specific surface area as samples obtained from the disintegrator DESI 11. The Samples which were ground separately had to be then homogenized in a laboratory homogenizer. The process of grinding and marking the samples is summarized in Table 1.

Table 1. The samples marking and the description of the grinding process.

Sample	Pre grinding 400 ($m^2 \cdot kg^{-1}$) Ball mill		Final grinding DESI 11		Final grinding Ball mill		Homogenization
	Separate	Co-grind.	Separate	Co-grind.	Separate	Co-grind.	
A	X	-	-	X	-	-	-
B	-	X	-	X	-	-	-
C	-	X	-	-	-	X	-
D	X	-	X	-	-	-	X
E	X	-	-	-	X	-	X