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Investigation of the effects of fatty acids on the compressive strength of the concrete and the grindability of the cement

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Abstract

In cement industry, a great energy consumption has been observed during grinding of clinker. To reduce this consumption, some waste products have been used as grinding aids.

In this investigation, the effects of sunflower oil (SO), oleic acid (OA), stearic acid (SA), myristic acid (MA) and lauric acid (LA) on the fineness and strength of the cement have been examined. These aids were added into clinker in certain ratios based on the cement clinker weight and the grinding has been done for a definite time at the same condition.

All of the fatty acids used increased the fineness as compared with the cement without the grinding additives. SO and OA decreased the strength significantly, LA decreased it to a lesser extent and SA increased it definitely according to the common cement. But MA did not alter the strength of the cement as much as SA. In addition, the covering of the balls influences the grinding of cement clinker unfavourably.

Keywords: Grinding; Cement clinker; Compressive strength; Surface area; Fatty acids

1. Introduction

In the cement industry, a great amount of the total electric energy consumption is consumed in grinding the raw materials and the clinker. Because of the diminishing available sources of energy and the attendant rise in energy costs, it is important to pay particular attention to this major cost item. In the cement industry, in order to reduce the energy cost, grinding aids are used. The most important functions of the chemical aids are to eliminate or retard the caking and agglomeration phenomena during the grinding process. In the cement industry, there are so many different materials used as grinding aids, including solids, such as graphite, oleoresinous liquid materials, volatile solids, and vapors [1–3]. From the chemical engineer's point of the view, there are very interesting studies in the literature. Among those studies, Serafin [4] and Fagerholt [6] reported that triethanolamine and phenol increased the Blaine surface area of the cement and the mill output. Lange [5] revealed that the use of diethylene glycol facilitated the grinding of portland masonry cement. Schenker et al. [7] found that addition of 0.4 wt.% of a first-run distillation product from trimethylolpropane manufacture to a standard cement mix before grinding improved the Blaine surface. Nikl and Marek [8] announced that size reduction of cement in the presence of the aqueous solution of phenolsulfonic acid or ethylbenzenedisulfonic acid gave products with specific surface increased by approximate 10%. Surana and Joshi [9] explained that the specific surface of a sample containing cement clinker, china clay and gypsum ground with 0.05% urea in the aqueous solution is 755 cm^2/g higher than that of a sample without the grinding aid. The effect of methyl alcohol, ethyl alcohol, acetone, benzene, diethyl ether on the grinding of cement clinker in a ball mill was investigated by Kim [10] and it was found that methyl and ethyl alcohol provided practical power saving and all of the aids decreased the compressive strength. Shakhbazyan and Mikhaelyan [11] analyzed the effect of the wastes composed

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of activated carbon and zinc acetate on the specific surface area of the ground clinkers. Furthermore, 0.08–0.5% hydrophobic agents based on the weight of clinker, such as calcium oleate, naphthenate, laurate, stearate or palmitate, or the free acids themselves are used at the clinker–gypsum grinding stage. But they may cause some retardation of setting [12]. Moreover, Hekal et al. [13,14] examined the mechanical and physicochemical properties of hardened portland cement pastes containing hydrophobic admixtures. In addition, the waterproofing characteristics of polymer-modified portland cement mortars have been studied by Saija [15]. Besides these references, as known, whether the additives used reduce the compressive strength according to the normal cement or not is very important.

The main aim in this research is to investigate the effects of sunflower oil (SO) acid, oleic acid (OA), stearic acid (SA), myristic acid (MA) and lauric acid (LA) on the specific surface and the compressive strength of the normal cement.

2. Experimental

2.1. Materials

Sunflower oil, oleic acid, lauric acid, myristic acid and stearic acid were supplied from Alemdar Chemical Industry, Gebze, Turkey. All the grinding additives used in this study are very cheap renewable chemicals, and obtained mostly from natural sources. For example, stearic acid, hard, white, waxlike solid of the composition $CH_3(CH_2)_{16}COOH$ melting at 69 °C, obtained from vegetable fats and oils. Myristic acid is a hard crystalline solid of the composition $CH_3(CH_2)_{12}COOH$ melting at 58 °C, obtained from coconut oil. Lauric acid occurs in high percentage in the oil of the coconut and other kernels of the tropical palm nuts. It is a saturated acid of the composition $CH_3(CH_2)_{10}COOH$ and is a semisolid melting at 44 °C. Oleic acid occurs in most natural fats and oils in the form of the glyceride. It is a complex acid and the composition of $CH_3(CH_2)_7CH$: $CH(CH_2)_7COOH$. Sunflower oil contains about 66% linoleic acid, 23% oleic acid, 4 % stearic acid and 6% palmitic acid. The chemical composition of the cement clinker and the properties of the balls are also given in Table 1.

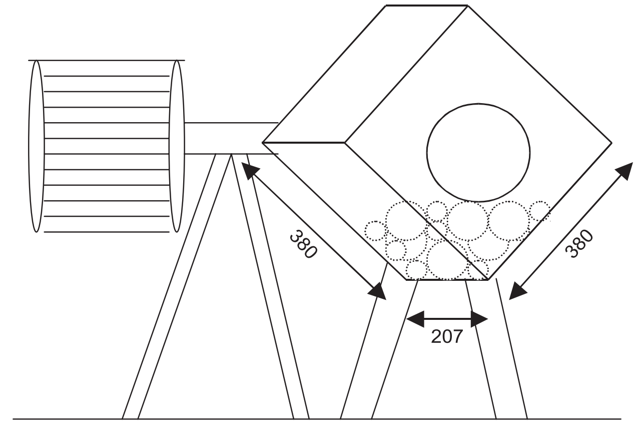

Fig. 1. The view of the box mill.

Table 1
Chemical analysis and properties of materials

Cement clinker		The size distribution of the balls		
Components	wt.%	Diameter (mm)	Total ball weight (kg)	Total ball number
SiO_2	22.18	60	4.343	5
Al_2O_3	5.57	50	2.541	5
Fe_2O_3	3.56	40	1.540	6
CaO	65.76	30	1.689	16
MgO	1.22	20	4.329	154
SO_3	0.45	10	8.830	771
Cl^-	0.0140			
Loss on ignition	0.31			
Na_2O	0.22			
K_2O	1.03			
TiO_2	0.28			
Free CaO	1.2			
Hydraulic module	2.1			
Silicate module	2.429			
Alumina module	1.563			
Lime standard	92.185			
C_3S	49.51			
C_2S	25.13			
C_3A	8.58			
C_4AF	10.65			

2.2. Methods

The total weight of 2000 g of the mixture was used for each experimental run. The mixture of 95% clinker (1900 g) and 5% limestone (100 g) was first put in the box mill. The total space volume of the box mill was 29.9 l. The balls occupied 17% of the space volume of the box mill. The speed and the grinding run time were 47 rpm, and 45 min, respectively. The shape and the dimensions of the box mill are given in Fig. 1.

2.2.1. Determination of fineness

The fineness was determined as the percent retained by sieving a sample of 10 g cement ground on 0.045, 0.090 and 0.200 mm screen opening according to ASTM C430-96 [16].

2.2.2. Determination of density

First, the ground cement sample weighted (m) was filled into the sample cup and then helium gas was passed through the cup placed into a closed part of multi pycnometer (Model MVP-1). After the volume (V) of the sample was calculated, the density was found by ρ=m/V formula according to ASTM C 188-95 [17].

2.2.3. Determination of Blaine surface

The specific surface was found by Blaine Star type ZZB/PC-MT according to ASTM C 204 [18].