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MINERAL COMPOSITION AND MICROSTRUCTURE OF CLINKER FROM RAW MIX CONTAINING METALLIC PARTICLES

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ABSTRACT

The influence of the presence of finely dispersed metallic particles on the mineral composition and microstructure of clinker minerals have been studied using chemical analysis and optical microscopy. The mineral composition to a great extent depends on the prevailing technological parameters: sintering temperature and concentration of Fe_2O_3. Abrasive slurry, containing finely dispersed metallic particles significantly influenced the mineral composition and microstructure of the cement minerals. The observed disintegration of the alite in general is attributed to the considerable increase in acidity of the liquid phase.

Introduction

The crystalline structure of cement clinker is determined by the sizes of alite and the belite crystals and the rate of reaction involving CaO. The granulometric composition of raw mix, that is the presence of various size grains of quartz, $CaCO_3$, clay, slag, etc.(above 100μm), greatly influence the morphology of clinker minerals [1]. The morphology of belite and alite to a great extent depends on the quantity and chemical composition of the liquid phase [2].

It is a well known fact that decreasing the aluminate module, p, to 0.32 - 0.64 enhances the formation of alite with hexagonal structure, smaller in size than those from higher p values. However, high aluminate module leads to crack formation on the mineral surface and possible partial and even complete dissolution of the clinker mineral crystals [3, 4].

This research, like an earlier publication [5], is aimed at investigating further the influence of localised Fe_2O_3 content, produced from oxidation of finely dispersed metallic particles on cement clinker mineral morphology using chemical and optical microscopy methods.

Experiment

Raw mixes were prepared using various composition as shown in Table 1 from dried raw materials. The raw mixes were grinded and pellets 12mm in diameter and 5mm in length, weighing about 2.5g were prepared using the hydraulic press.All samples were burnt at 1380

TABLE 1

Composition of Raw Mix and Free CaO Content of Clinker, Mass %

Raw material composition						Free CaO content mass %, °C	
No of sample	Lime-stone	Abrasive slurry	Abrasive slurry burnt at 400°C	Open hearth slag	sand	1380	1420
1	81.00	3.30		6.7	9.0	3.5	1.0
2	79.63	7.56		6.81	9.0	0	0
3	82.00		2.0	7.0	9.0	0.4	0.1
4	80.30		3.3	7.4	9.0	0	0
5	82.00	5.00			13.0	2.8	0.4
6	82.00		5.0		13.0	0	0
7	81.00			9.0	10.0	0	0

and 1420°C for 30 min. in an electric furnace using a silicon heater, and quenched in air to ambient temperature. All samples produced at 1380°C were analysed chemically [6] and examined by optical microscopy. The lime saturation coefficient, LSC, the silicate, n, and the aluminate module, p, were calculated using their respective formula, while the composition of the clinker was calculated using the Kind V. A. formula [7].

Results and Discussion

The chemical analyses of the various samples are presented in Tables 2 and 3. Results of chemical analysis show that samples 3 and 4 can be used to produce normal portland cement. However, the low aluminate module value, p, and insignificant quantity of C_3A indicates that slow setting and hardening cement were produced. Earlier results has shown that cement produced from raw mix containing abrasive slurry, consists of mainly C_6AF_2 solid solution [5]. The calculated C_4AF value in Table 2 should be considered as mean value of calcium aluminoferrite solid solution lying between the C_2F - C_6AF_2.

The probability of producing normal portland cement using the three component raw mix, except for sample 5, is very high. The major problem encountered during sintering is the early

TABLE 2

Chemical Analysis and Module Values of Clinker

Chemical composition, mass %						Module		
No of sample	CaO	Fe_2O_3	Al_2O_3	SiO_2	Total	LSC	n	p
1	64.5	9.6	3.6	21.3	99.0	0.86	1.61	0.37
2	58.6	17.4	3.8	20.2	100	0.81	0.95	0.22
3	66.1	4.4	4.4	23.1	98.0	0.88	2.63	1.00
4	65.1	5.8	4.8	23.0	98.7	0.86	2.17	0.83
5	62.8	12.1	1.8	23.2	99.9	0.84	1.67	0.15
6	66.1	5.4	3.9	24.4	99.8	0.84	2.60	0.72
7	67.8	2.6	3.8	25.8	100	0.84	4.00	1.50

Note: All calculations are for clinker produced at 1380°C

TABLE 3
Mineral Composition of Clinker

N of sample	Mineral composition, mass % C_3S	C_2S	C_3A	C_4AF	Total
1	48.6	25.6	6.7	17.1	98.0
2	33.0	33.0	17.4	18.1	101.5
3	56.2	23.8	4.2	13.4	97.5
4	50.7	27.7	2.9	17.6	98.9
5	48.1	30.3	15.7	8.6	102.7
6	48.3	33.6	1.3	16.5	99.6
7	51.1	35.6	5.6	7.8	100.4

Note: All calculations are for clinker produced at 1380°C.

(a)

(b)

FIG. 1.
Optical photographs of sample 5 burnt at 1420°C (a) and 1380°C (b).

FIG. 2.
Optical photograph of sample 6 burnt at 1380°C.

FIG. 3.
Optical photograph of sample 7 burnt at 1380°C.

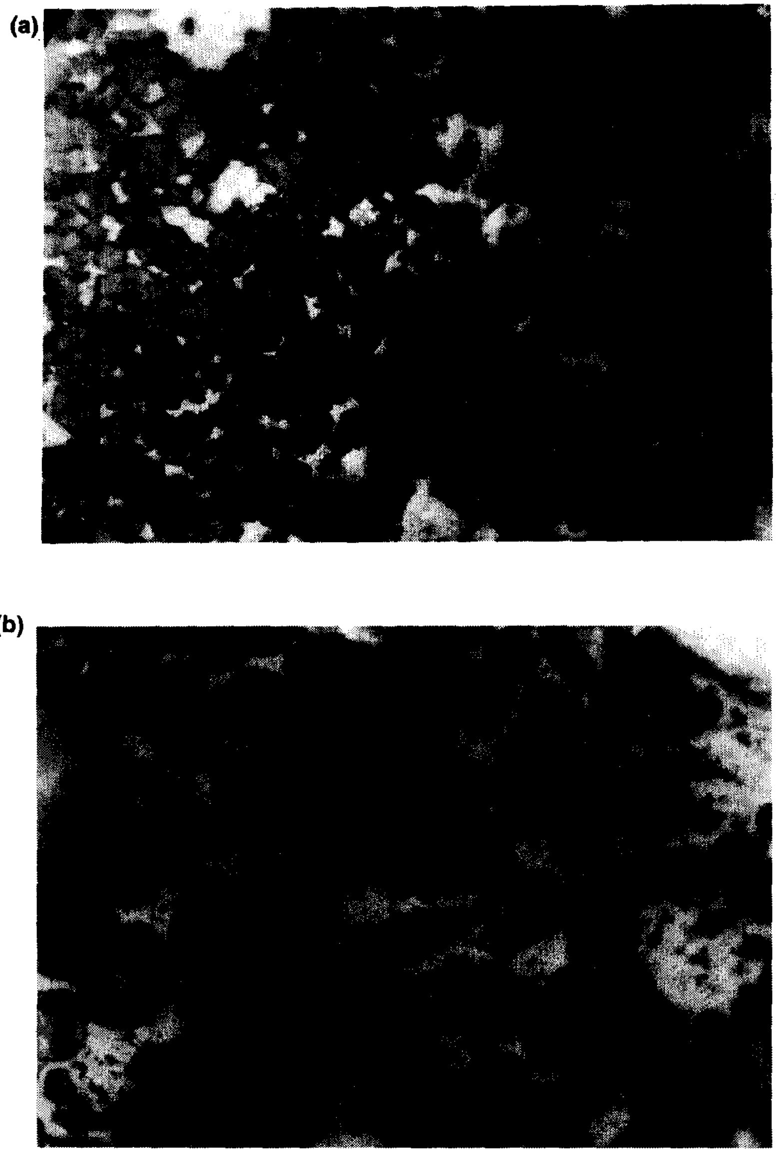

FIG. 4.
Optical photographs of samples 3 (a) and 4 (b) burnt at 1380°C.

formation of the liquid phase. However, this can be overcome with proper optimisation of the raw mix composition.

Optical photographs of sample 5, burnt at 1420°C show that the alite crystals were exceptionally long (A) when compared with standard alite from clinker of natural origin (Fig.1a). The presence of 3.8 mass % free CaO in the sinter 5, despite the high Fe_2O_3 content, indicate that the iron oxide was localised in the raw mix. At lower temperature, 1380°C, belite crystals were the dominant phase (Fig. 1b).

(a)

(b)

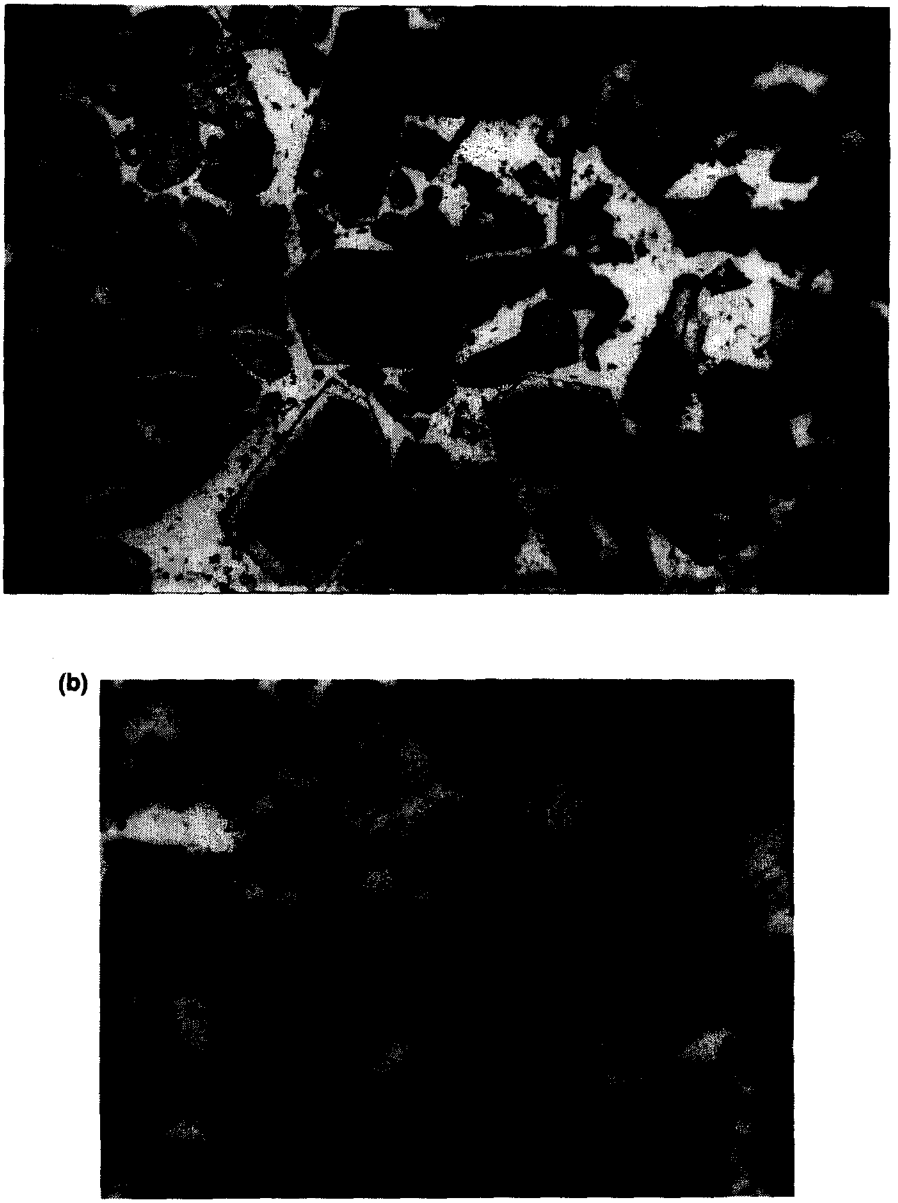

FIG. 5.
Optical photographs of samples 1 (a) and 2 (b) burnt at 1380°C.

Optical photographs of sample 6 containing the same quantity of abrasive slurry preheated at 400°C, show the formation of uniform size clinker mineral crystals predominantly of belite Fig.2). Photographs of sample 7 do not differ from 6 in its morphology (Fig.3). Significant deviation in the values of calculated alite and belite content and that observed using the optical microscopy, especially for samples 6 and 7, could be attributed to the low sintering temperature.

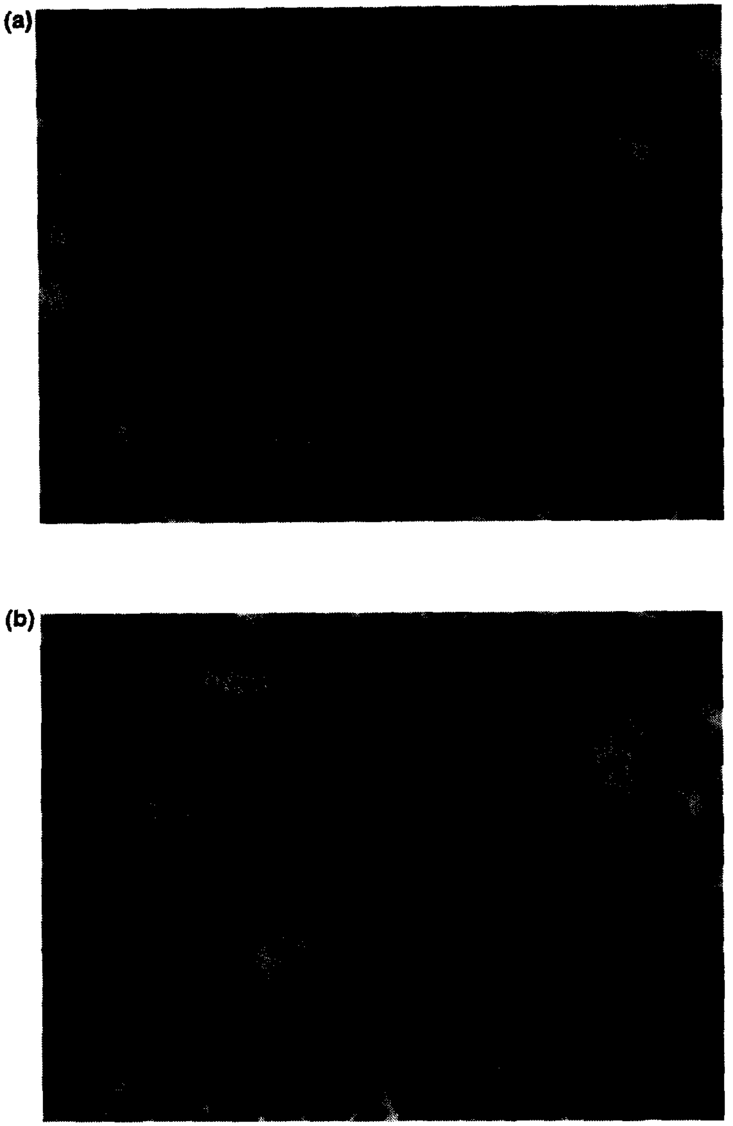

FIG.6.
Optical photographs of samples 1 (a) and 2 (b) burnt at 1420°C.

Analyses of optical microscopy photograpgs of samples 3 and 4 burnt at 1380°C show the predominance of uniform size hexagonal alite crystals 20 - 30μm in length (Fig.4). Samples 1 and 2, burnt in the same condition, have higher liquid content and larger alite crystals predominantly 50-80μm in length (Fig.5). This could be attributed to early formation of a large quantity of liquid phase and consequently enhanced migration of the CaO and SiO_2. However, sample 1 contains 3.5 mass % free CaO, and the produced minerals are somewhat localized.

Increase in burning temperature of sample 1 and 2 to 1420°C led to the alite and belite loosing their characteristic forms (Fig.6). Increase in the quantity of small size crystals, 10 - 30μm, high distortion in the clinker mineral morphology and the dissolution or disintegration of the individual minerals are directly linked to high Fe_2O_3 content and the consequently the increased acidity of the liquid phase.

From the analyses, it can be said that chemical analysis in isolation can not be used in determining the mineral composition of cement clinker. The mineral composition to a great extent depends on the prevailing technological parameters, such as sintering temperature and concentration of individual oxides most especially the Fe_2O_3.

Abrasive slurry significantly influenced the microstructure of cement minerals by considerably increasing the acidity of the liquid phase. This is responsible for the observed disintegration of alite mineral and distortion in cement minerals morphology in general.

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