Pergamon

Cement and Concrete Research, Vol. 25, No. 3, pp. 459-464, 1995

0008-8846/95 $9.50+.00

0008-8846(95)00032-1

POND ASH - A POTENTIAL REACTIVE RAW MATERIAL IN THE BLACK MEAL PROCESS OF CEMENT MANUFACTURE BY VERTICAL SHAFT KILN (VSK) TECHNOLOGY

By

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(Communicated by M. Daimon)
(Received November 10, 1994)

ABSTRACT

Pond ash from thermal power plants serves as a reactive raw material in the black meal process of cement manufacture. Plant scale trials in a 50 TPD VSK plant have shown encouraging results in terms of quality improvement, energy conservation and enhanced production. Clinker produced was easy to grind resulting in saving of grinding energy.

INTRODUCTION

In India most of the thermal power plants use wet system for disposal of ash. The bottom ash from the boilers and the flyash from the precipitators are mixed together and pumped off in the form of slurry to lagoons where water is drained off or recycled. This material is being referred as `Pond ash' in our investigation.

The precipitator ash is finer and the fineness increases with each stage of collection. This material has unburnt carbon particles and is black in colour. The particle size of pond ash varies depending upon the degree of pulverisation of coal, associated impurities in coal, boiler type, power load and efficiency of collection systems.

Pure fly ash has been tried in rotary kilns as a replacement of clay (1,2,3). Chatterjee et al (4) attempted seven percent replacement of clay with fly ash having composition similar to that of clay and found that there was reduction in the moisture content of slurry from 43 to 40 percent in a wet process plant together with increase in the kiln output. However, high sulphur content in some fly ashes may create operational problems in the dry process rotary kilns with preheaters. Similar attempts can be made with pond ash in black meal process although no literature is available on this material.

In India pond ash disposal is a problem for most of the thermal plants. The objective of this investigation is to highlight the feasibility of using pond ash as a raw material ingredient in the black meal process.

EXPERIMENTAL

MATERIALS

The plant scale trials were conducted in a 50 TPD VSK plant near Kanpur. This plant normally uses high grade limestone from Satna, highly plastic clay from nearby dried ponds, mill scale from mild steel rolling mills of Kanpur as a corrective material and breeze coke from TISCO Jamshedpur. Gypsum is procured from RSMDC, Rajasthan. Pond ash was procured in a wet state from nearby Panki thermal power plant. The ash had about 30 percent coarse particles and remaining fine particles. Incoming lots revealed variations in quality with 8 to 16 percent unburnt carbon. The wet ash was sun dried over concrete platforms manually, prehomogenised and bulk heap of about 20 MTs was made for the trial. The chemical composition of the materials are given in Table 1.

Table 1.
Chemical composition of materials (mass%)

Materials	LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Others
Limestone	40.3	3.9	1.2	0.2	51.5	2.0	-
Clay	12.0	56.8	19.6	6.8	2.2	1.2	
Breeze coke	72.5	15.7	5.9	3.5	1.4	1.0	
Mill scale	-	-	-	78.0*	-	-	*also contains FeO
Gypsum	-	-	-	-	-	-	Purity - 81.7
Pond ash	17.4	49.6	22.0	4.5	2.2	0.6	Na_2O=0.6,K_2O=1.0, TiO_2=0.8,P_2O_5=0.5, Sulphur=0.5

METHOD

The plant normally uses a four component raw mix. Each component was extracted from RCC silos and weighed individually as per requirements. Dry pond ash was used as the fifth component. The five component mix was then ground in an open circuit raw mill and the black meal produced was pneumatically blended in blending silos. The checked and corrected black meal was nodulised in a pan type noduliser and the green nodules uniformly sprayed in the VSK by means of rotary feed chute. Representative samples of control and experimental clinker were collected only under steady conditions of kiln.

Pond ash was increased in increments of 0.5 percent and necessary changes in the proportions of other components were made. It was found that 4 percent addition was most appropriate under existing conditions in that plant. A retention of 12±0.5 percent on 90μ sieve was maintained in case of raw mix under both control and experimental conditions. Both representative samples of control and experimental clinker were ground to almost same fineness separately in a laboratory ball mill with 3 percent gypsum. Clinker without pond ash addition in raw mix in referred as the control clinker while with the pond ash is referred as the experimental clinker.

Determination of all physical parameters and chemical testing were done in accordance with Indian Standard Specifications IS:4031-1988 and IS:4032-1985 respectively.

Hydration in polythene bags (W/S=0.5) at room temperature (30±2°C) were stopped at different intervals of time with the help of isopropyl alcohol and ether. The samples were dried at 105°C for one hour, sealed in polythene bags and stored in a desiccator.

Non-evaporable water content (W_n) of the hydrated samples were determined by drying them at 105°C to constant weight and then from the weight loss at 1000°C for one hour. X-ray diffraction patterns of some of the hydrated samples were also recorded. Litre-weight was measured by filling sieved clinker of size 6 to 12 mm dia in one litre volummetric flask and then weighing the material.

RESULTS AND DISCUSSION

The chemical and mineralogical compositions of the control and experimental clinker are given in Table 2.

Table 2 shows that loss on ignition (LOI) and free lime contents are reduced and the combined lime and C_3S content are increased in the experimental clinker as compared to that of control. This indicates that experimental clinker is better in quality than the control. Reduction of free lime from 2.2 to 1.6 percent is an indication of good burnability. This is supported by the litre weight data. On an average there is an increase of 80 g/litre weight from the control to the experimental clinker. Minor variations in litre weight of experimental clinker indicates smooth operation of the shaft kiln. Further an increased kiln output by 10 percent indicated faster rate of burning in presence of pond ash. Another significant feature of the experimental clinker is the stabilisation of the autoclave expansion (Table 3). Reduction in autoclave expansion was probably because of the incorporation of magnesia in aluminate and ferrite phases leaving small quantity of periclase. This was possible due to higher amount of melt phase brought about by reactive oxides and glassy phases present in the pond ash. Formation of more quantity of lumps is an indication of the formation of higher amounts of liquid phase

The greatest advantage during clinkerisation in presence of pond ash was a net saving of fuel consumption by 2 percent. It came down from 12 to 10 percent consumption on raw mix. This could be possible due to the residual carbon of the pond ash and the formation of early and larger amount of liquid phase. Further dusting was drastically reduced which might be due to higher content of liquid and C_3S phase and better cooling.

An improvement in the quality of clinker in presence of pond ash may be due to higher C_3S content and microstructural modifications of the clinker phases, Blanco and Varela (5) found that when fly ash was used in raw mix during clinkerisation, certain amount of alite was formed even at 1200°C and in the finished product the alite content was higher by 5-8 percent as compared to one obtained without fly ash. In the present case pond ash might also be playing the same role and the C_3S crystals obtained at lower temperature might be acting as a seed crystals for C_3S formation when the liquid phase appears. Also it has already been reported by Maki and Kato (6) that presence of alkalies and sulphates in presence of MgO and appropriate rate of heating and cooling affects the morphology of alite phase. In the present investigation the cooling of clinker was better due to long blower running hours.

The clinker was jet black in colour with almost fully burnt cores. When it was ground with gypsum in the cement mill of the plant, in the case of experimental clinker better output was achieved for same specific surface area. This showed that in the present of pond ash, it is easy to grind the clinker. It was further observed that additions of pond ash beyond 4 percent lead to handling problems. The free lime produced in the experimental clinker was soft in nature as indicated by low Le-chatelier expansion (Table 3). This property could be utilised for making blended cements with higher pozzolana contents.

The quality improvement because of the presence of pond ash in the raw mix of experimental cement can further be confirmed by hydration characteristics (Table 3). The variation of non-evaporable water contents with hydration time is shown in Fig, 1. From the figure it is clear that the

Table 2.
Chemical and Mineralogical composition

CLINKER	Chemical Composition (Mass%)							Moduli values			Potential phases %			
	LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	f-CaO	SM	A/F	LSF	C_3S	C_2S	C_3A	C_4AF
CONTROL	1.2	20.6	6.3	4.6	63.2	3.6	2.8	1.89	1.37	0.92	40.5	28.5	8.9	14.0
EXPERIMENTAL	0.6	20.0	6.8	4.8	63.8	3.7	1.6	1.72	1.42	0.95	48.7	20.6	9.9	14.6

Table 3.
Physical data of cements

CEMENT	w/c (%)	Sp. surface M^2/Kg	Setting (min.)		Soundness		Compressive strength (MPa) (days)				Hydration Studies Non-evaporable Water (W_n) (days)			
			IST	FST	Le chat (mm)	Autoclave (%)	1	3	7	28	1	3	7	28
CONTROL	24.5	306.5	135	230	6.0	Failed	18.0	26.0	34.2	45.0	8.5	10.1	11.4	14.9
EXPERIMENTAL	25.0	309.5	140	235	2.0	stabilised*	19.0	30.5	40.0	48.5	8.8	10.2	15.2	17.8

*0.45% autoclave expansion after 7 days aeration

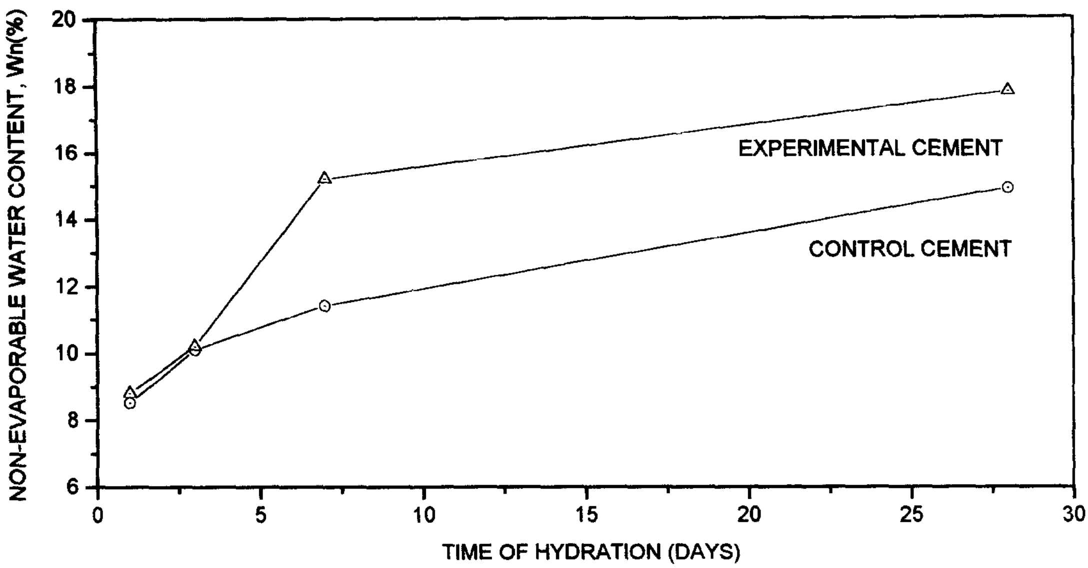

Fig. 1. Variation of non-evaporable water contents with hydration time of control and experimental cement

extent of W_n increased with time in both control and experimental cement. However the W_n values are higher in the case of experimental cement at all ages of hydration but the values are significantly higher at 7 and 28 days of hydration. The X-ray diffraction patterns of the hydrated samples indicates that experimental cement hydrates faster than the control.

The variation of compressive strengths is shown in Fig. 2. As the hydration progressed the compressive strength increased but the values are always higher in the case of experimental cement.

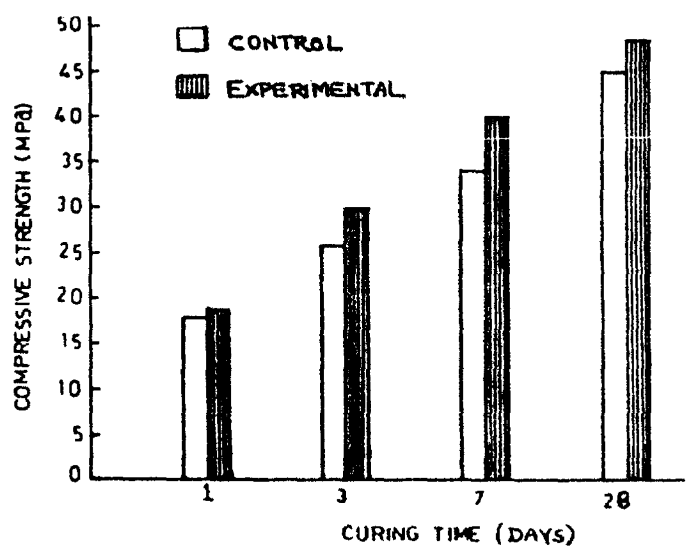

Fig. 2. Variation of compressive strength of mortars made from control and experimental cements with curing time

The higher compressive strengths may be due to higher amount of C_3S present in the experimental cement.

CONCLUSIONS

Pond ash is a useful reactive material in the black meal process of cement manufacture. It improves the quality of cement and the burnability of overall black meal leading to enhanced production. Pond ash in raw mix also lowers fuel consumption and the grinding of clinker becomes easier. Volume instability due to high magnesia in lime stone can be tackled to some extent by use of pond ash.

ACKNOWLEDGEMENTS

The authors are thankful to Prof. S. Giri, Head of Chemistry Department, University of Gorakhpur, Gorakhpur for providing necessary laboratory facilities. Thanks are also due to the authorities of M/S Vikram Cement (Pvt) Ltd., Kanpur for carrying out the trials in their plant. Financial support from CSIR, New Delhi is gratefully acknowledged.

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