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CEMENT RAW MIX CHARACTERIZATION BY DIFFERENTIAL THERMAL ANALYSIS

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ABSTRACT

The choice of the raw mix for the manufacture of cement has a great bearing on the energy required for the clinkerization. Differential thermal analysis technique provides a convenient method for estimation of such heat requirements. Cement raw mixes of varying chemical and mineralogical compositions and belonging to some Indian Cement plants have been studied and characterized by differential thermal analysis. Results indicate that the different raw mixes from the same raw materials consume different energies and the method adopted can be utilized for choosing the optimum raw mix.

INTRODUCTION

Cement clinkering involves a highly energy intensive process. Theoretically only 420-430 kcal/kg is required for the formation of final clinker phases[1]. However in actual process it requires between 750 kcal (dry process) to 1450 kcal (wet process) per Kg of clinker. Cement raw mixes are designed primarily from the points of view of operational convenience and cement quality besides other techno-economic considerations, and seldom for saving energy. Owing to energy crisis this aspect has been brought to focus recently.

Since large enthalpy changes[2] are associated in the process of cement manufacture, differential thermal analysis (DTA) provides a very convenient tool for characterizing cement raw mixes. The heat required for clinkerization of two cement raw mixes, designed from the same raw materials was determined by a simple technique using DTA. The technique[3] followed reveals that DTA can prove useful in choosing a particular raw mix for the actual process, keeping in view its heat requirement for clinkerization. The difference in the heat requirements of the two raw mixes was of the order of 40 kcal/Kg of clinker.

EXPERIMENTAL METHODS

The raw materials chosen were limestone LS-1 and LS-2 and laterite (LAT). The oxide composition of these materials is given in Table 1. Using these raw materials, two raw mixes were designed with the propor-

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tions and various moduli values, as given in Table 2. DTA curves of the two mixes Mix I and Mix II were recorded from ambient to 1450°C on Mettler

TABLE 1

Chemical Analysis of Raw Materials

S №	Raw Material	Oxide composition on ignited basis %					LOI
		SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	
1	Limestone (LS-1)	14.62	1.09	3.21	78.64	0.65	38.33
2	Limestone (LS-2)	24.03	1.41	4.29	69.22	0.36	35.25
3	Laterite (LAT)	14.59	31.22	35.04	18.52	-	23.05

TABLE 2

Raw Mix Proportions and Moduli values

Raw Mix	Composition			Moduli Valves		
	LS 1%	LS 2%	LAT %	LSF	SM	AM
Mix I	14	78	8	0.902	2.12	1.76
Mix II	10	82	8	0.884	2.15	1.77

Thermo analyzer TA-1 using a heating schedule of 15°C/min and α-Al_2O_3 as the reference material. DTA curves of Al_2O_3 Vs Al_2O_3 and that of pure (AR Grade) $CaCO_3$ were also obtained under similar experimental conditions. The DTA curve of Al_2O_3 Vs Al_2O_3 was superimposed (Fig 1) on the DTA curves of the two raw mixes and the resulting endothermic and exothermic areas were measured. The total theoretical heat (TH) required for clinkerization was calculated as:

$$TH = H_t (A) + H_t (B) - H_t (C)$$

where H_t (A) is the heat required for heating 1g of Al_2O_3 from ambient to 1450°C. This heat energy was calculated by using the standard expression[4,5] for the molar specific heat of Al_2O_3 as a function of temperature. H_t (B) and H_t (C) are heats corresponding to the areas below (endothermic) and above (exothermic) the DTA curve of Al_2O_3 (Fig 1). The respective heat energies were estimated by calibrating these areas with the area of the endothermic peak in the DTA curve of $CaCO_3$ which was assigned[3] a heat equivalent of 392 cal/g. Following the above procedure the values arrived at are given in Table 3.

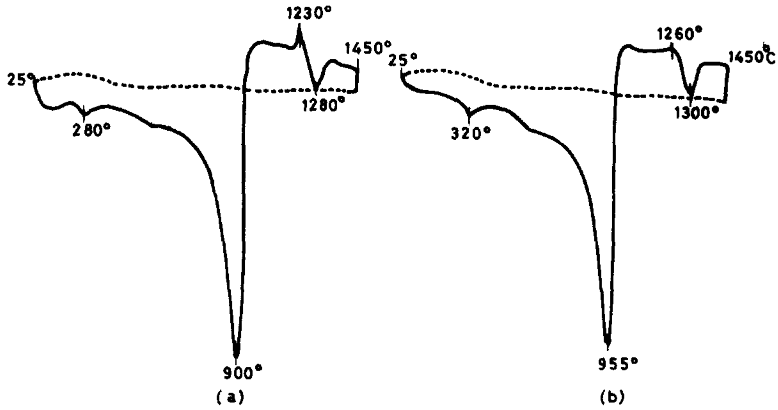

FIG 1 DIFFERENTIAL THERMAL ANALYSIS CURVES OF THE CEMENT RAW MIXES MIX-I(a) & MIX-II(b) AND ALUMINA (-------- --)

TABLE 3

Heat requirement for clinkerization and phase composition

S No	Raw Mix	Heat required for clinkerization Kcal/Kg	C_3S%	C_2S%	Interstitial %
1	Mix I	897.74	48	28	24
2	Mix II	857.79	44	30	26

Microscopic analysis was also carried out on the clinkers made from Mixes I and II for estimation of various phases which are also reported in Table 3.

RESULT AND DISCUSSION

From the above it is observed that the difference in the heat energies for clinkerization of two raw mixes designed from the same raw materials is of the order 40 kcal/Kg. Further the microscopic analysis shows that the clinker corresponding to these from both mixes do have the acceptable phase compositions. It can be also observed from Tables 2 and 3 that Mix I is a hard mix and will require higher burning temperatures. The method presented can be conveniently used for choosing a particular raw mix requiring optimum heat for clinkerization assuming the rest of the system remains unchanged. Similar studies conducted on various Indian Raw mixes showed that the method discussed can be utilized effectively.

CONCLUSIONS

1 A method of determining the heat requirement for cement raw mix clinkerization by using DTA, developed at CRI, is proposed as a routine test.

2 It has been established that the technique can be conveniently used for choosing an optimum raw mix.

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