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UTILIZATION OF RICE HUSK ASH FOR THE PRODUCTION OF CEMENT – LIKE MATERIALS IN RURAL AREAS

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The design of a simple village – level incinertor is described. The chemistry, differential thermal analysis and x-ray diffraction of Rice Husk Ash produced in this incinerator have been studied. The process for the production of cement – like material from Rice Husk Ash is described and its properties studied.

INTRODUCTION

About one million tons of rice husks are produced every year as a result of rice–husking in Pakistan. Untill recently its use was limited and mostly discarded as waste. When viewed on a global scale the figure for the amount of waste is substantial. Efforts are being made to study the properties and develop new uses of this material.

In 1958 Ahsanullah, Chaudhry and Chotani [1] studied the properties of mixtures of cement with rice husk ash(RHA). The thermal conductivity curves for various compositions of cement and RHA were anomalous. They concluded however that the mixture furnishes a building material of considerable practical utility. Qureshi [2,3] gave a theoretical explanation for the anomalous minima and maxima in the thermal conductivity curve and indicated the pozzolanic activity of RHA. However, Mehta's [4] work in USA gave a new impetus to research on RHA and the local work was restarted with a view to producing a cement–like material.

The present paper reports the development of a simple low cost incinerator for burning rice husks under controlled conditions to produce rice husk ash of the desired quality which can be used to produce cement–like material. The aim of this study was to evolve a process which should be simple, and which involves equipment and machinery that could be fabricated locally.

DESIGN OF THE INCINERATOR

Rice Huskh(RH) are difficult to incinerate and do not liberate heat the way other organic substances do, although the heat derived from one lb of RH is about 6000 Btu. Efforts were made, therefore, to design an incinerator which would give RHA with minimum organic carbon residue and desired activity (caustic soda soluble SiO_2 more than 50 %).

A used 45 gallon mild steel oil drum (dia 22″) (Fig. 1) was converted into a continuous incinerator. A grill (4 holes/in) was placed 6″ above the base. Two doors 8″ x 6″ were provided, one below and the other above the grill. The lower door was used for initially starting the fire and controlling the air draught, whereas the upper door was used for withdrawing the ash. A separate chimney, with 4″ dia

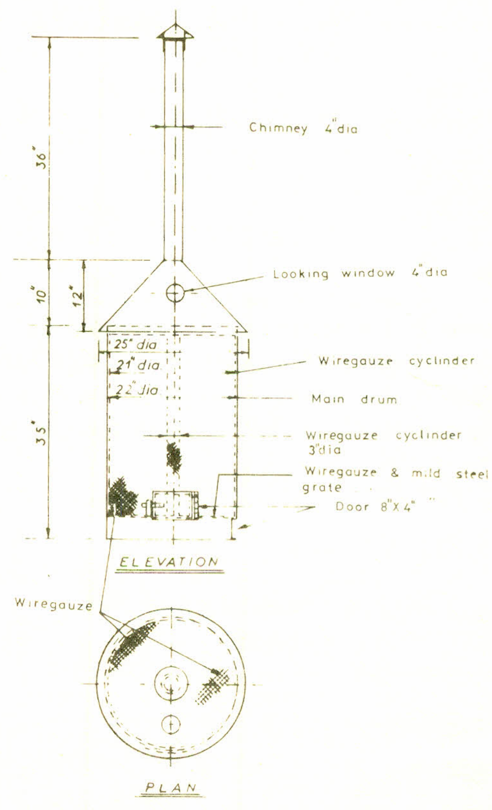

Fig. 1. Rice husk incinerator

window, was placed on the top of the drum. No extra fuel was required except to start the burning. The process of burning is self-sustained and does not require any adjustments or control. However, the burning of rice husk(RH) was found to be incomplete. The design of the incinerator was modified by placing a wire – gauze (4 holes/in) cylinder of 3″ dia in the centre. This improved the quality of the product but it was still not very satisfactory. In order to supply more air to RH beds another wire–gauze (4 holes/in.) cylinder of 21″ dia was placed in the drum. This modification gave the incinerator temperature at about 700^o and the product was light–grey in colour with about 80 % silica activity. The active silica was estimated by boiling 1 g of ash in 50 ml. of N/2 NaOH for 15 minutes.

COMPOSITION OF RHA

Chemical Composition. The elemental composition of RHA obtained from the incinerator is given in Table 1.

Table 1. Chemical composition of RHA. (in %)

SiO_2	88.40
Al_2O_3	1.99
Fe_2O_3	0.57
CaO	1.68
MgO	0.40
Na_2O	0.45
K_2O	1.69
P_2O_5	0.40
MnO	0.04
L.O.Ign.	4.00
Total	99.42

It seems that some alumina is also taken up by the husks along with silica. Other elements (Ca,Mg,K,P,Mn,Fe) are essential for the growth of the plant. The loss of ignition (4 %) appears to be due to carbonates and organic carbon.

Table 2 gives the water soluble constituents of RHA(5g. in 100 ml. H_2O, boiled).

Table 2. Water soluble constituents. (in %)

CaO	0.14
MgO	0.20
Na_2O	0.05
K_2O	1.23

It is interesting to note that little CaO and Na_2O are extracted with water whereas more than 50 % of MgO and 72 % of K_2O are in a water-soluble form. The lower amount CaO in the water soluble portion indicates that lime is in the form of calcite.

Differential Thermal Analysis. The ash was analysed by differential thermal analysis using a high sensitivity setting (Fig. 2). A small endotherm occurs at about 100^o due to absorbed moisture. A very broad exotherm with a peak at 420^o indicates oxidation of residual carbon. Another small endotherm occurs at about 600^o which is close to that of the quartz inversion (α-quartz to β-quartz). It seems that a small amount of amorphous silica is converted into quartz at the incinerator temperature (700^o).

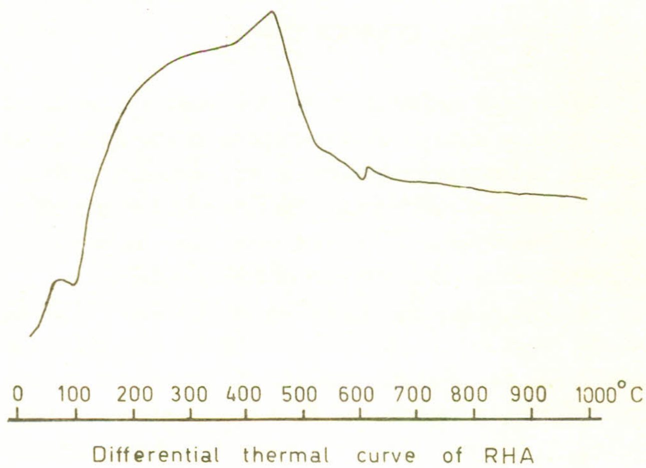

Fig. 2. Differential thermal curve of RHA

X-ray Differaction. An X-ray diffraction photograph of RHA was taken with an exposure of six hr. The pattern shows much scattering with only two reflections which have been identified tentatively as 101 (d=3.36 Å) of quartz and 101 (d=3.03 Å) of calcite; both of weak intensities (20 and 15 respectively). The amorphous nature of the bulk of the material is evident by the fact that quartz normally gives a very good pattern with two hours of exposure.

AVAILABILITY OF LIME

Limestone is abundantly available throughout the country and costs Rs 25–40 per ton at the pit head. Lime is sold at the rate of Rs. 250/– to Rs. 300/– per ton ex–kiln. These kilns are spread all over the country which produce very good quality lime. Most of these kilns use natural gas as fuel.

PRODUCTION OF CEMENT–LIKE MATERIAL FROM LIME–RHA/LIME–RHA–SURKHI

A series of mixtures of (i) slaked lime and RHA and (ii) slaked lime + RHA + Surkhi (burnt clay) with the slaked lime ranging from 10–40 % were thoroughly mixed and tested for their physical characteristics as cement. Two compositions H (slaked lime 30 %, RHA 70 %) and HS (slaked lime 30 %, RHA 50 % and Surkhi 20 %) were found satisfactory for semi-pilot plant production. The materials were mixed and ground as follows:

The mixture Lime–RHA/LIME–RHA–Surkhi is first ground in a disc grinder which reduces the material to about 80–100 mesh. This ground material is transferred to the rod mill fabricated in the Laboratories from a ball mill and ground to get the surface area of 4200 sq. cm/g

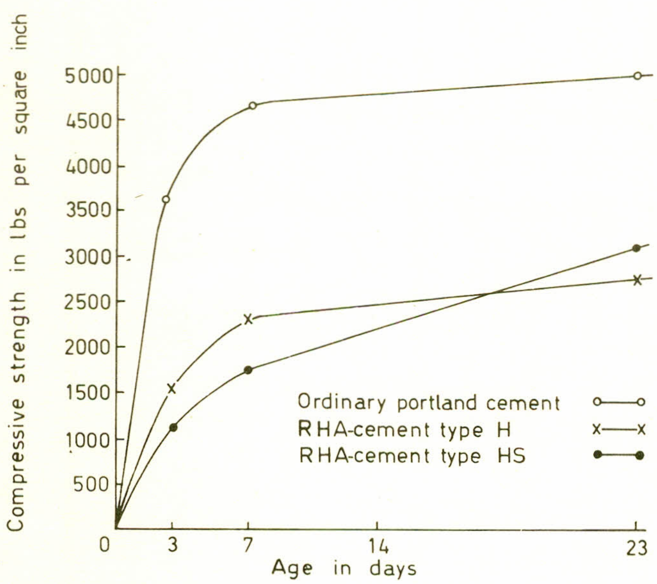

Fig. 3. Compressive strengths of 1:3 mortar at rice husk cement and ordinary Portland cement.

(Blaine). The rods being used at present are hardened mild steel rods.

PROPERTIES OF RHA CEMENT

Table 3 gives the physical properties of the two types of cement and ordinary portland cement (OPC). The Fig. 3 gives a comparison of the development of compressive strength with time over a period of 28 days. The trend of the curve clearly shows that rice husk ash cement plus surkhi(HS) will further develop strength with the passage of time.

The setting behaviour of the cements are similar to that of portland cement. Numerous tests have shown that the initial and final setting time are within BSS 12 limits. From the value of the compressive strength obtained under different conditions it is clear that it develops strength in a manner parallel to that of portland cement. The strength values are superior to hydraulic limes and natural cements of the types A.S.T.M. Designation 10–54 (1961), and to Masonary cements of the type ASTM C–91–70.

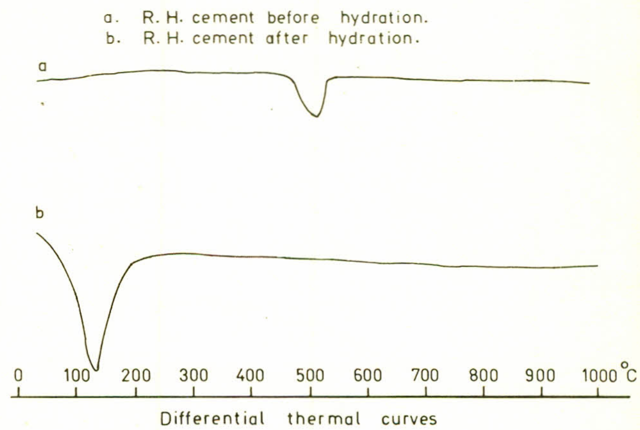

Fig. 4. Differential thermal curves.

Table 3. Physical properties of rice husk ash cements and opc.

		H	HS	OPC
1.	Cement type	H	HS	OPC
2.	Loss on Ignition	8.0%	7.0%	4.00%
3.	Fineness (Blaine)	4200.sq.cm/g	4250.sq.cm/g	3800.sq.cm/g
4.	Bulk density	0.75 g/ml	0.83 g/ml	1.5 g/ml
5.	Specific gravity	2.10 g/ml	2.3 g/ml	3.02 g/ml
6.	Water for normal consistency	60%	56%	30%
7.	Soundness (Le chatetlier expansion in mm)	Nil	Nil	Nil
8.	Setting time			
	Initial	165 min	355 min	180 min
	Final	255 min	595 min	420 min

The strength obtained at 28 days is about 66 % of the strength of portalnd cement tested under similar conditions. Efforts are being made to improve the early strength of the selected cement compositions by additives.

The bulk density (0.75 g/ml) of the cement is low compared with 1.5 g/ml of the portland cement and fineness is high, hence the water requirement for normal consistency is also high (56–60 %). In all these tests standard sand has been used as required by B.S.S.

The D.T.A. of the cement before hydration gives a medium peak at 525^{o} due to the dehydration of $Ca(OH)_2$ (Fig. 4). After setting at room temperature the $Ca(OH)_2$ peak vanishes and a large peak appears at about 130^{o}, most likely due to the dehydration of tobermorite (CaO,SiO_2, nH_2O). The X-ray diffraction pattern of the set cement indicates that the bulk of the material is amorphous, with two lines of poor intensities (3.36 Å and 3.05 Å) indicating the presence of some quartz and calcite.

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