International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Preparation & Characterization of Insulating Rice Husk Ash Refractory using Rice Husk as Pore Forming Agent

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Abstract: ***Preparation of the Insulating Silica Refractory was done by utilizing the waste Rice Husk Ash taken from rice mills. These insulating properties can be obtained by controlling the porosity of the sample by using different amount of rice husk as pore forming media and different firing temperatures. Experimental compositions were prepared by RHA whose chemical composition were determined by X-RF. Rectangular samples were prepared using hydraulic press. Physical properties like Apparent Porosity was found to be favorable for Thermal Insulation and was observed to be increasing with increasing the amount of pore forming agent (Rice Husk). Mechanical strength were found to be good considering the porosity present. In addition the Crystalline phase were also been studied by XRD analysis.***

Keywords: Pore forming agent, Waste Rice Husk, Rice Husk Ash, Insulation, Silica.

1. Introduction

Globally, 650 Tons of Rice Paddy are produced every year. Around 20% of the rice paddy produces Rice Husk. Rice husk is produced as a waste from its grain during its processing in rice mills and its removal during rice refining. It creates disposal problem [1]. This rice husk generally contains 70-80 % organic matter such as cellulose, lignin etc. and rest 20-30% mineral components such as silica, alkalis and trace elements [2-5]. When rice husk is burnt into open environment, it produces another residue called Rice Husk Ash. This burnt RHA has different chemical, mineralogical and morphological characteristics depending on the process acquired during burning of the husk as well as on the rice variety, soil chemistry, climatic conditions, and even the geographic localization of the culture [6-7].

Insulation silica refractories are generally used for insulation lining of furnace or kiln so that energy efficiency can be maintained which responds into cost beneficiation as well as reduction in the production of flue gases.

It contains 60-70% of SiO_2 which comes from raw-material used like quartz and clays. Here, silica can be provided through RHA as it contains it in amorphous phase. This amorphous silica shows better reactivity than crystalline silica present in quartz. So, insulation silica refractories can be successfully prepared using RHA [8-11].

In the present Investigation, we have studied the effect of pore forming agent used in insulation refractory prepared by RHA. Here rice husk its self was used as pore forming agent in different amount in different samples prepared. It's also noted to be a benefit as most of the raw- material of this insulation refractory has come from waste.

2. Materials & Methods

2.1 RH & RHA

RHA were collected from rice mill where RH is used as a fuel. This RHA has already been burnt around 400°C several times in the furnace in the mill. So, it has a trace amount of volatile matter which provides us a potential to use it directly without any further treatment. The chemical composition was determined by using the X-ray fluorescence (XRF) spectrometer according to ASTM C114-00.

Table 1: Chemical composition of rice husk ash by XRF

Compound	*Concentration (%)*	*Compound*	*Concentration (%)*
SiO_2	85.3	ZnO	0.11
P_2O_5	3.8	CuO	0.058
K_2O	2.37	Rb_2O	0.036
CaO	1.42	BaO	0.03
Fe_2O_3	0.817	ZrO_2	0.02
MgO	0.81	Re_2O_7	0.02
MnO	0.312	Y_2O_3	0.012
RuO_2	0.271	Eu_2O_3	0.01
SO_3	0.23	Cr_2O_3	0.014
TiO_2	0.18	NiO	0.008

It was found that RHA contains 85% of SiO_2. So, it can be used as a raw- material for the replacement of quartz in insulation silica refractory.

The XRD analysis of RHA were recorded from 10° to 90° range of 2Θ in ―Rigaku Mini Flex-II desktop X-ray Diffractometer". The XRD pattern of the rice husk ash (RHA), shown in Fig. (1), indicates that silica in the rice husk exists in the amorphous form only.

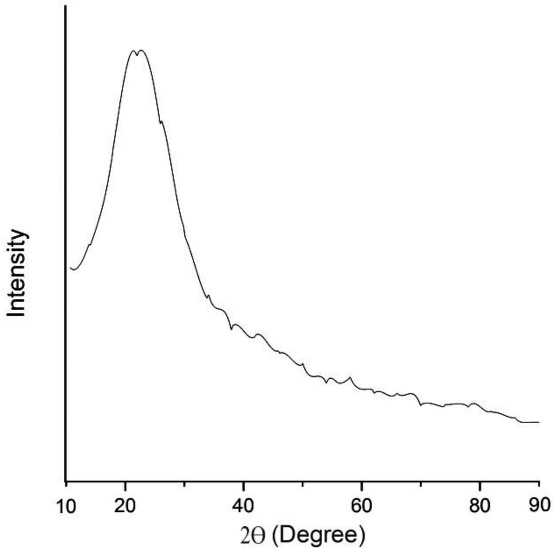

Figure 1: XRD Analysis of RHA

Rice husk has about 80% of volatile matter which is removed when it is set to burn at 200° to 500°. It can be assumed that if RH powder is used in as pore forming agent than during the sintering of the body, it will produce pores by combusting itself which is a fundamental requirement of insulating refractory. This was confirmed by performing the Thermal Gravimetric Analysis (TGA) up to 1000°C in air atmosphere with heating rate of 10°C/min in ―Setaram-Scientific and Industrial Equipment (Model no-560/51920)"

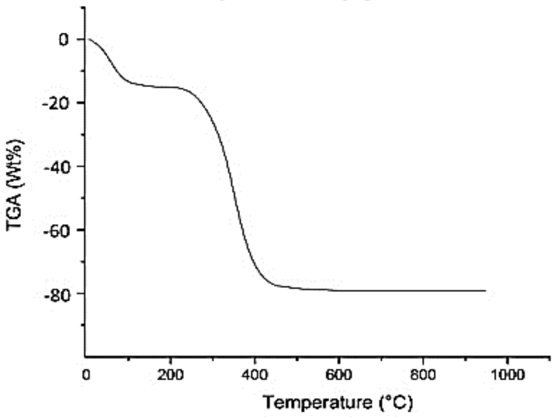

Figure 2: TGA curve for RH up to 1000°C.

2.2 Sample Preparation

The fabrication of the refractory was done from several different formulations containing rice husk ash, rice husk, clay as binder and refractory grog for strengthening. Different sample prepared are tabulated in Table-2. Mixing of constituents was done manually for 20 minutes in dry condition. By following semi-dry process, least amount of water was used. The rice husk ash refractories were formed by the pressing method in a hydraulic press and moulded into rectangular form. The clay also provided green strength to the body and better workability.

Table 2: Percentage of Rice Husk

Sample	S-1	S-2	S-3	S-4	S-5	S-6
% Rice Husk	5	10	15	20	25	30

2.3 Drying & Sintering

The prepared samples were allowed to dry in an electric oven at a temperature of 105°C for 6hrs. The samples were sintered in a ―Bysake & Co. Electric Furnace (Model No-7054)" with a heat schedule of room temperature to 500°C in 4hrs and thereafter up to 1180°C in 2hrs. The soaking period was kept 1 hour and cooling was done for 7hrs.

3. Result & Discussion

3.1 Apparent Porosity & Bulk Density

The boiling water method described in the ASTM C20 [12] was used to determine the apparent porosity (AP) and the bulk density (BD). It has been observed that porosity increases gradually with increasing the amount of RH.

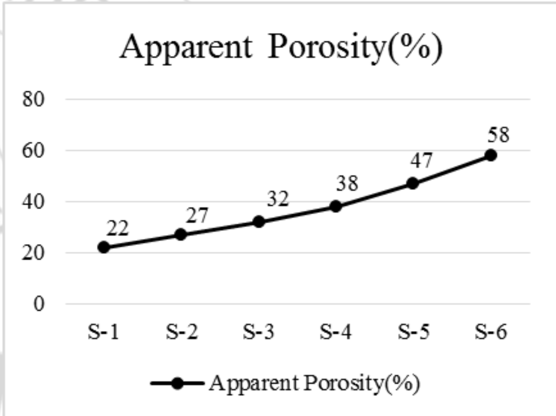

Figure 3: Apparent porosity of Sintered Samples

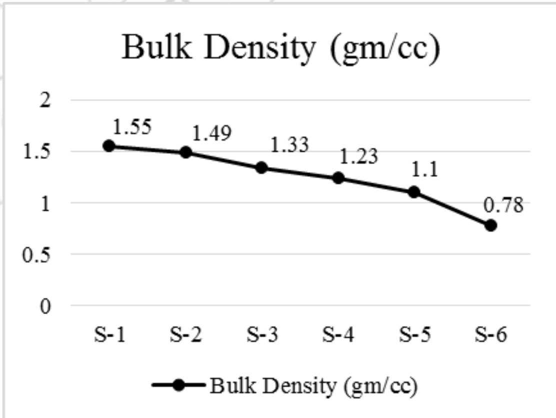

Figure 4: Bulk Density of Sintered Samples

3.2 Modulus of Rupture

The MOR was determined according to ASTM 133 [13]. It has been seen that MOR of these insulation refractory as very good considering the amount of porosity present in them. It may be a result of incorporating refractory grogs and clay into the composition which enhanced these mechanical properties of the product.

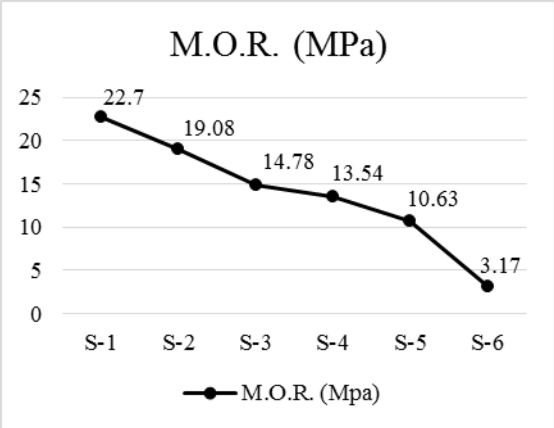

Figure 5: Modulus of Rupture of Sintered Samples

3.3 Thermal Conductivity

Standard method for determining thermal conductivity of refractories by Hot Cross-Wire method as per ASTM C-1113 were used. The thermal conductivity tests are particularly important for insulating refractories where the thermal gradients from the hot face to the cold face dictate the use of a refractory material for the specific uses. The tests were performed at 800°C. The low thermal conductivity values of this Insulating refractory may be due to their porous nature, grain boundaries and other microscopic imperfections.

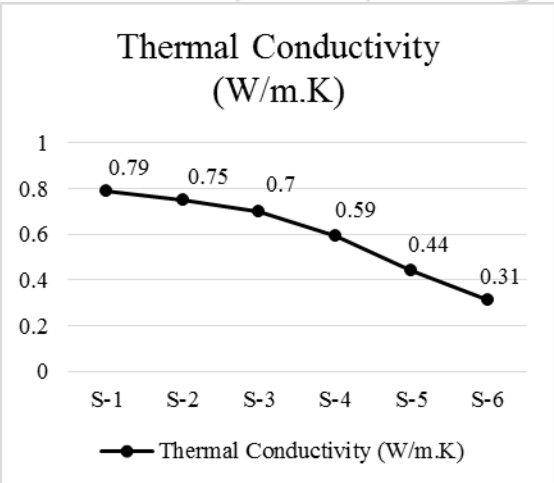

Figure 6: Thermal conductivity at 800°C

3.4 X-Ray Diffraction Analysis

XRD analysis were done for sample S-5 due to its promising insulation properties. XRD were done at 2ϴ, 10° to 70°. The pattern is studied using JCPDS file to identify the phases developed after sintering. The result confirms the presence of crystalline silica (SiO_2) as the major phase in the rice husk ash refractory. The polymorphs of silica present include both the cristobalite and tridymite.

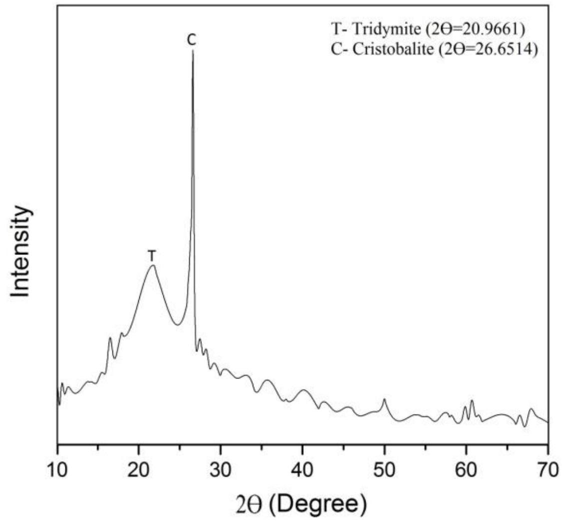

Figure 7: XRD analysis for RHA insulation refractory

4. Conclusion

1) The insulating refractory prepared using RHA as the source of silica and RH as Pore forming agent produced excellent properties in terms of bending strength (MOR) as well as in insulation (Thermal conductivity).
2) The sample S-5 having 25% of RH has shown excellent insulating property with sustainable mechanical strength. Increasing further amount of RH resulted in an increase in insulation but MOR is decreased drastically. So, the maximum amount of RH as pore forming agent can be limited up to 25%.
3) It can be observed that RH (as pore forming agent) is favourable for our purpose as when it is combusted, it produced pores in the body and the residue is RHA itself giving silica to the system.
4) The raw-materials used here to prepare insulating refractory contains only industrial wastes like RH, RHA and grogs. It is the key to the benefit in terms of waste disposal as well as its utilization.

5. Acknowledgement

We are grateful to the faculty and staff of Department of Ceramic Engineering, IIT (BHU), Varanasi, India for providing the proper facilities to accomplish this work.

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